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Differences in Occupational Stress by Smoking Intensity and Gender in Cross-sectional Study of 59,355 Japanese Employees using the Brief Job Stress Questionnaire (BJSQ); The Niigata Wellness Study

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ABSTRACT

Objectives It has been hypothesized that smoking intensity may be related to occupational stress. This study aimed to investigate whether stress, including problems with superiors or co-workers, is a driver of smoking.

Methods Participants were 59,355 employees across multiple occupations who completed a self-reported questionnaire-based occupational stress survey using the Brief Job Stress Questionnaire (BJSQ). Stress scores for the BJSQ subscales were summed up after assigning high points for high stress and then converted to Z-scores based on the mean of all participants. Heavy-smokers (HS) smoked ≥15 cigarettes/day and light-smokers (LS) smoked <15 cigarettes/day and were compared to non-smokers (NS).

Results The main subscale items that were significantly associated with smoking status in both genders included "physical burden," "irritation," and "physical symptoms." In the analysis including smoking intensity, the stress score for “co-workers’ support” was significantly lower for LS men than NS (NS 0.091 ± 0.98, LS -0.027 ± 1.00, HS 0.033 ± 0.99), and was significantly higher for HS women than NS (NS -0.091 ± 1.00, LS -0.080 ± 1.05, HS 0.079 ± 1.03). However, it was low among LS aged ≤39 years women in the manufacturing industry.

Conclusions It was speculated that LS men and some of LS women gained "co-workers’ support" using smoking as a communication tool while reducing the amount of smoking. The existence of such "social smokers" suggested that in order to promote smoking cessation, measures are essential to improve communication between workers in addition to implementing smoking restrictions in the workplace.

Strengths and limitations of this study

- The strength of this study is that it is the first large comprehensive survey of more than 50000 individuals in East Asia, and a wide range of components of occupational stress, including supports of superiors or co-workers.

- In addition to a simple comparison of smokers and non-smokers, we compared heavy-smokers and light-smokers separately to clarify stress factors characteristic of women who are heavy-smokers and men who are light-smokers, which have not been well studied.

- We have also added industry-specific surveys to clarify co-workers' supportive conditions according to smoking rates in workplaces.

- A limitation of this study is that it was a cross-sectional study and therefore causal relationships could not be identified.

INTRODUCTION

Smoking is not only a personal health problem that presents a significant risk for conditions such as malignancies and cardiovascular and respiratory diseases but also is a serious public health challenge, such as workplace secondhand smoke and work productivity issues.[1-4] Most studies that include both smoking and occupational stress consider both as risk factors for non-communicable diseases and habits such as those related to drinking, overeating, and exercise. Only a few studies have focused directly on the relationship between smoking and occupational stress.[5-9]

There are multiple aspects to occupational stress, and various stress models have been developed to elucidate causal associations with occupational stress. Among them, workload (job demand) and work discretion (job control) are widely accepted as representative models. These models have been extensively used to investigate the association between cardiovascular disease and work stress while the association between smoking and stress indicators has been controversial. For example, Kouvonen and colleagues reported that lower “job control” was associated with increased smoking intensity among civil servant women in Finland while no such association was found in men.[7] Kawakami and colleagues using a model that added support by co-workers and supervisors as buffering factors suggested that the intensity of smoking increased in Japanese men in a group with low job control and low social support,[8] suggesting that social support is a key factor in the intensity of smoking. Studies using other indicators also found that "low confidence in workplace organizations" was associated with smoking,[9] and "poor trust relationship with superiors" was associated with smoking in women managers.[5] On the other hand, the opposite result was reported where "good workplace support" was associated with smoking among women in the nursing profession.[10] However, because of the very limited number of large-scale comprehensive studies of a variety of industries in the East Asian region, where smoking rates are known to be high, no consistent conclusions can be drawn on the

association between various occupational stresses, such as lack of workplace support, and smoking.

Therefore, we administered a detailed occupational stress survey, including smoking intensity and workplace support, to approximately 60,000 employees from industries of different sizes and categories to determine the relationship between smoking intensity and occupational stress and differences in the relationship by gender, age, and industry. This would elucidate occupational stresses peculiar to smokers. Ameliorating that stress would be useful for promoting smoking cessation.

METHODS

Survey participants

Among 64,279 employees who underwent an occupational health examination and stress check based on the Occupational Safety and Health Act between Apr. 2016-Mar. 2017 in Niigata Prefecture, 34,865 men (mean age 41.8 years) and 24,490 women (mean age 41.9 years) participated in this study. Excluded were employees whose gender was unknown, had incomplete examination data, an incomplete stress check response, or were ≤19 years old or ≥70 years old. The industry type was classified according to a large number of persons working at seven occupations and a smaller number of workers in an eighth category designated as "other".

Patient and Public Involvement

Patients were not involved in this study.

Stress check

The 57-item “Brief Job Stress Questionnaire” (BJSQ) developed and validated by Shimomitsu and colleagues was used to assess occupational stress.[11] It has been used in previous studies as well as in workplaces across the country by the Ministry of

Health, Labour and Welfare in guiding the Stress Check Program.[12] The purpose of this program was to assess stress in individual workers and in the work environment, and its results were reported to be associated with long-term leave and turnover of workers. [13, 14] Participants were required to answer questions on the BJSQ using a Likert scale of one to four points. The BJSQ contains several related questions, which are added together to produce a result for each category. The total score for each category resulted in high points for high stress (simple total score). Question content was broadly divided into three components: "Job Stressors," "Mental and Psychological Stress Reactions ("Stress Reaction") ", and "Social Support." "Job Stressors" has nine subscales (job demands, job control, meaningfulness of work, work environment, suitability for work, physical burden, skill utilization, required job quality, interpersonal relationships), and "Stress Reaction" has six subscales (vigor, irritation, fatigue, anxiety, depression, physical symptoms). Originally, "Social Support" included four subscales (superiors, co-workers, family and/or friends (family), life satisfaction), but "life satisfaction" was excluded because it was not related to support resources. Its elimination left three subscales. Scores were tabulated for each of these three components and 18 subscales.

These simple total scores were compared and examined using z-score values (z-scores) standardized from the average score of participants for each subscale and each component of each subscale. Results with reference to the simple total scores are presented in Suppl. Table 1.

Smoking status and intensity

Information on smoking status (smokers or non-smokers) and the number of cigarettes smoked per day was obtained from the medical checkup questionnaire. Based on the median number of cigarettes smoked in the all-smokers (AS) group, we defined those who smoked <15 cigarettes/day as light-smokers (LS) and those who smoked ≥15 as

heavy-smokers (HS). In the LS, HS, and non-smoker (NS) groups, the distribution of chronological age was calculated in ten-year increments and the stress check scores (z-scores) were compared among the three groups.

Analysis of "Co-workers' support" by industry type and age

In addition, to investigate differences by industry and age, we divided the participants into two age groups (≥40 years or ≤39 years) and compared the "co-workers' support" subscale by the industry category.

Statistical analysis

Smoking was compared between the AS and NS groups using unpaired t-tests for all 18 subscales, and additionally compared using nominal logistic analysis adjusted for age, BMI, amount of alcohol drinking, and drinking frequency. Three of the subscales with significant differences were selected in order of increasing odds ratios. Participants with positive or zero Z-scores on the selected subscales were classified as stressed (+) and those with negative Z-scores were classified as stressed (-) to form two groups. Nominal logistic regression analysis was performed on eight combinations of three subscale stresses (+) or (-), adjusting for age, body mass index (BMI), amount of alcohol drinking, and frequency of drinking.

Regarding smoking intensity, the Z-scores of the three components of the BSJQ and the 18 subscales were compared for the NS, LS, and HS groups by the Dunnett test with NS as the control. Z-scores were examined by multivariate analysis adjusted for age and BMI, amount of alcohol drinking, and drinking frequency. Additionally, an examination of "co-workers' support" by industry and age group compared the NS, LS, and HS groups by multivariate analyses adjusted for BMI, amount of alcohol drinking, and drinking frequency.

JMP for Macintosh (14.0.0) was used for statistics.

Ethical Considerations

The study was approved by the Ethics Committee of Niigata University [2017-0401], and we have obtained consent for the use of personal information from all participants on the health checkup. After confirming the concordance of the data, personal information such as the participant's name, personal identification code for health checkup orders, and the name of the company or office to which the worker belonged was removed before using the data for analysis.

This study does not involve animal subjects.

RESULTS

The smoking rate for the entire study population was 13.6% for women and 41.4% for men. For both genders, the smoking rate by age group was highest in the 40s and the lowest in the 20s. There were more LS and fewer HS among women in all age groups. In men, the number of the LS was greatest among those in their 20s. The industry category with the lowest smoking rate was civil servants of both genders (Table 1). Mean age of women smokers was significantly older than for NS; in addition, both LS and HS were significantly older than NS. Among men, LS were significantly younger than NS, and HS were significantly older than NS. In women, BMI was significantly lower in LS and higher in HS than in NS, but no significant difference was observed between NS and AS. In men, BMI was significantly lower in AS and LS than in NS, but there was no significant difference in BMI between HS and NS (Table 1).

As shown in Table 2, many of the stress subscales were independently and significantly associated with smoking, but the three highest odds ratios for both genders were for "physical burden," "irritation," and "physical symptoms." Conversely, "co-workers' support" had the lowest odds ratio of all subscales, especially for men. The risk

increased with the combination of the three factors of “physical burden,” “irritation,” and “physical symptoms” for both genders (Table 3).

Compared with NS, the BJSQ simple total score for women AS had significantly higher stress values than for NS in all components (Suppl. Table 1). When compared to NS by smoking intensity (Fig. 1), Z-scores for almost all subscales for women HS were significantly higher, with only "job demands," "suitability for work," and "required job quality" being not significantly different between NS and HS. Results of the multivariate analysis for all “Social Support” subscales also showed that HS women had significantly higher Z-score values than NS women.

In men, the AS group had slightly but significantly lower scores for “Social Support” than the NS group (Suppl. Table 1). According to smoking intensity, the “Social Support” score compared with NS was significantly lower in LS by multivariate analysis, but no statistical difference was observed between NS and HS (Fig. 1). Significantly higher stress scores were shown for "job demands" and "required job quality" in LS than in NS.

Since “co-workers’ support” differed from the other subscales in that smokers were less stressed than NS, we added an analysis that included industry type and chronological age (≤39 years vs. ≥40 years) (Fig. 2). In the case of women, HS was more stressful compared to NS in only the medical and welfare industry in those ≤39 years old. Other industries showed no significant difference because the number of HS was small. Among LS ≤39 years old in the manufacturing industry, stress scores were significantly lower than in NS. Among men, HS ≥40 years old and LS ≤39 years in the manufacturing industry and LS aged ≤39 years in the service industry were less stressed compared with NS in the same industry classes.

DISCUSSION

This study is the first large-scale study to investigate a wide range of components of occupational stress and smoking intensity using the BSJQ. We have clarified occupational stress specific to smokers the following three points. (1) Subscales independently associated with smoking in both genders were "physical burden", "irritation" and "physical symptoms". (2) Women HS were generally highly stressed. (3) Men LS obtained more "co-workers' support" even though they had higher stressors such as "job demands."

The reason why smoking status was strongly associated with "physical burden" rather than "job demands" is that "small breaks to rest the body" may be strongly linked to smoking and become a habit in the manufacturing, transport, and construction industries. "Job demands" primarily identifies the degree of psychological burden whereas "physical burden" was evaluated by only one question asking whether the work involved physical labor. In an earlier occupation-specific survey, Strickland and colleagues reported nearly twice the rate of smoking among white construction workers compared with whites in general in Missouri, US.[15] Chau and colleagues examined work content in assessing "physical job demands" and reported that workers with a higher total amount of physical work, such as "working under bad weather" and "using vibration tools," smoked greater numbers of cigarettes in the Lorene region of France.[16] This is probably because such workers often work on the same team and recognize smoking as a "means of dealing with work difficulties." Furthermore, smokers recognize that smoking can relieve the "irritation" that they feel as occupational stress, but this "irritation" can also occur as symptoms of nicotine withdrawal due to a temporary interruption of smoking during work.[17] In addition, nicotine withdrawal can be manifested by dizziness and palpitations**.** Parrott in a review stated that smokers tended to report high "daily" stress and that stress symptoms such as irritation increase when they cannot smoke frequently, and that successful quitters

experience reduced “stress.”[18] Strictly speaking, these complaints by smokers may not be "physical symptoms" of occupational stress.

The reasons why women HS were highly stressed are complex. Women HS generally have high scores for "Job Stressors" such as "job control," "work environment," and "interpersonal relationships," and they may be engaged in low discretionary tasks in the first place. In addition, it was shown that women smokers were more likely than men to express negative emotions, such as anxiety, regarding the stress response;[19] biological and socio-environmental ‘sex differences’ are being explored.[20] Similarly, the results of "Social Support" suggested that women HS engaged in tasks with less support than NS. Conversely, the stress by lack of social support may have led women to smoke. Creswell and colleagues reported that in general "social support" aided in the success of smoking cessation.[21]

In men, there might be a kind of “social smoking” because smokers reported better “Social Support” than non-smokers. Earlier reports captured the phenomenon that college student smokers smoked only when they were with friends and acquaintances,[22, 23] and the presence of youth who habitually smoked only on social occasions, such as at parties, became recognized. They were reported to display positive actions in preventing secondhand smoking by non-smokers.[24] Even in Japan, smokers who "do not smoke at home" exist, and their restrained smoking style was reported.[25] However, it is speculated that these individuals may also be a type of social smoker based on the fact that small-volume smoker men in workplaces, which was highlighted in the current survey, reported more “co-workers’ support.” This way of smoking, which is highly related to peers, has been defined as "peer smoking".[16, 26]

Research on social support and smoking in the workplace suggested that smoking functioned as a communication tool. In China, where the smoking rate is as high as 38%, it is highly speculated that supervisors and co-workers are smokers, so smokers are more likely to obtain support by supervisors.[27] A study in North America reported

(smoking rate: 26%), supervisors' support inhibited smoking, but co-workers' support did not inhibit smoking.[28] In addition, a study of Brazilian civil servant men (smoking rate: 17%) reported that social support suppressed smoking.[29] Thus, the association between "social support" and smoking may be explained by differences in the workplace smoking rate, with better relationships between non-smokers in environments with a low smoking rate and better communication between smokers in workplaces with high smoking rates. Men LS probably have sufficient knowledge about the health hazards of smoking to suppress their smoking intensity. However, they may be psychologically unable or fail to initiate smoking cessation because they may be afraid of losing social support in a workplace with a high smoking rate. Indeed, interventional surveys of smoking cessation guidance have reported that workplaces with a higher percentage of smokers have a stronger impact on peer smoking behavior and lower rates of long-term smoking cessation.[26]

Smoking rates may also be a factor in "co-workers' support" scores. Among women, "co-workers' support" was better for LS than NS in the manufacturing industry. The smoking rate among women in the manufacturing industry was relatively high at 15.8%, and it is estimated that women also obtain "co-workers' support" through smoking in such workplaces. These findings seemed to mean that good communication through smoking in a workplace could occur if the smoking rate was relatively high.

Promoting smoking cessation among youth is desirable for their health, and smoking regulations may be acceptable especially for young social smokers due to their behavioral characteristics. Common social smoking measures in workplaces include bans on smoking on workplace premises and during working hours.[30] The amended Health Promotion Law, which came into force in Japan in 2020, has in principle prohibited smoking indoors in many workplaces, pushing smoking regulations one step further. Simultaneously, even under a smoking ban, it will be necessary to promote communication among workers, for example by increasing opportunities for informal

information exchange across departments in the workplace, thereby making the act of obtaining support through smoking meaningless.

Significance and limitations of this study

The strength of this study is that it is the first large comprehensive survey of more than 10000 individuals in East Asia. Therefore, this study was able to investigate the association between a wide range of occupational stresses and smoking intensity across multiple occupations, suggesting for the first time that workplace stressors and supportive conditions may differ according to smoking rates in workplaces and by gender.

A limitation of this study is that it was a cross-sectional study and therefore causal relationships could not be identified. Factors such as working hours that could not be investigated at this time might contribute to the association between smoking and physical burden. Also, because the number of cigarettes smoked was provided by self-report in a health checkup questionnaire, responses may be inaccurate, such as inputting less than the actual dose. Reports by electronic cigarettes and heated tobacco products users may not have been accurate because it is difficult to translate these products into the number of cigarettes smoked or because users are not aware of them as tobacco products.

CONCLUSIONS

The occupational stress of smokers of both genders may be related to the subjective "physical burden," "irritation," and "physical symptoms." In analyses of smoking intensity and gender, both strong psychosomatic stress symptoms such as "irritation" and "physical symptoms" and lack of social support at work were observed in women HS; however, in contrast, overall smokers' “co-workers’ support” was good in men. In addition, in young LS in the manufacturing industries women, where the smoking rate

is relatively high, we observed significantly better “co-workers’ support” compared to that in NS, suggesting the presence of "social smokers" who continue to smoke small amounts as a communication tool in these workplaces.

These results suggest that improvement of the communication environment among workers may be essential for the promotion of smoking cessation at the same time as smoking bans in worksites and public facilities.

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Contributorship statement

ST, KK, and HS planned and designed the study. MT, KM, MO, and KS did project administration, funding acquisition and data collection. ST and KK calculated data for the statistical analyses, and did the literature review and wrote the first draft of the manuscript following discussion with all authors, and MK, AK, KF, and HS contributed to the editing of the manuscript. All authors participated in data interpretation, commented on subsequent drafts, approved the final manuscript, and agreed to submit for publication.

Declaration of interests

The authors declare no conflict of interest.

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Data sharing statements

No additional data available.

Table 1. Demographics of Study Participants (n=59,355) [Light-smokers=<15 cigarettes/day; Heavy-smokers≥15 cigarettes/day; SD=standard deviation; BMI=body mass index]

Participants	Women					Men				
Smoking status		Non-smokers	Smokers				Non-smokers	Smokers		
			All smokers					All smokers		
smoking intensity				Light-smokers	Heavy-smokers				Light-smokers	Heavy-smokers
Average (SD)										
Age [y]	41.9 (12.2)	41.7 (12.4)	43.3 (10.6) [a]	43.0 (10.9) [b]	44.2 (9.8) [b]	41.8 (12.5)	41.4 (13.0)	42.3 (11.8) [a]	38.5 (12.0) [b]	44.4 (11.2) [b]
BMI [kg/m^2]	21.76 (3.90)	21.77 (3.89)	21.71 (3.98)	21.55 (3.84) [b]	22.09 (4.26) [b]	23.20 (3.72)	23.29 (3.76)	23.08 (3.68) [a]	22.70 (3.60) [b]	23.29 (3.71)
Total Participants										
n <smoking rate %>	24,490	21,148	3,342 <13.6>	2327 < 9.5>	1015 < 4.1>	34,865	20,438	14,427 <41.4>	5219 <15.0>	9208 <26.4>
Age group (y)										
20-29	4,936	4,544	392 < 7.9>	313 < 6.3>	79 <1.6>	7,068	4,698	2,370 <33.5>	1404 <19.9>	966 <13.7>
30-39	5,771	4,958	813 <14.1>	575 <10.0>	238 <4.1>	9,050	5,100	3,951 <43.7>	1658 <18.3>	2292 <25.3>
40-49	6,293	5,150	1,143 <18.2>	743 <11.8>	400 <6.4>	8,404	4,561	3,843 <45.7>	1085 <12.9>	2758 <32.8>
50-59	5,537	4,746	791 <14.3>	558 <10.1>	233 <4.2>	6,756	3,762	2,994 <44.3>	733 <10.8>	2261 <33.5>
60-69	1,953	1,750	203 <10.4>	138 < 7.1>	65 <3.3>	3,587	2,317	1,270 <35.4>	339 <9.5>	931 <25.9>
Industry category										
Service agent	1,368	1,157	211 <15.4>	145 <10.6>	66 <4.8>	2,329	1,296	1,033 <44.4>	346 <14.9>	687 <29.5>
Medical and welfare	5,121	4,424	697 <13.6>	511 <10.0>	186 <3.6>	1,907	1,205	702 <36.8>	365 <19.1>	337 <17.7>
Transportation	774	641	133 <17.2>	85 <11.0>	48 <6.2>	4,354	2,240	2,114 <48.6>	416 < 9.6>	1698 <39.0>
Civil servant	3,355	3,178	177 < 5.3>	137 < 4.1>	40 <1.2>	2,299	1,651	648 <28.2>	277 <12.0>	371 <16.1>
Construction industry	366	314	52 <14.2>	34 < 9.3>	18 <4.9>	2,072	1,010	1,062 <51.3>	227 <11.0>	835 <40.3>
Retail business	3,639	3,040	599 <16.5>	405 <11.1>	194 <5.3>	3,632	2,212	1,420 <39.1>	566 <15.6>	854 <23.5>
Manufacturing	8,396	7,070	1,326 <15.8>	906 <10.8>	420 <5.0>	15,689	9,183	6,506 <41.5>	2674 <17.0>	3832 <24.4>
Other	1,471	1,324	147 <10.0>	104 < 7.0>	43 <2.9>	2,583	1,641	942 <36.5>	348 <13.5>	594 <23.0>
Alcohol drinking Amount (drinks/day)										
-2.2	18,470	16,481	1,989	1,419	570	17,064	10,947	6,117	2,333	3,784
2.3-4.4	4,511	3,614	897	639	258	11,398	6,233	5,165	1,889	3,276
4.5-6.6	1,212	867	345	209	136	4,807	2,447	2,360	733	1,627
6.7-	297	186	111	60	51	1,596	811	785	264	521
Frequency										
rarely	12,528	11,220	1,308	906	402	10,717	6,996	3,721	1,331	2,390
occasionally	8,533	7,501	1,032	760	272	12,042	7,446	4,596	2,062	2,534
everyday	3,429	2,427	1,002	661	341	12,106	5,996	6,110	1,826	4,284

[a] $p<0.05$ vs. non-smokers (unpaired t test), [b] $p<0.05$ vs. non-smoker (Dunnett's test)

Table 2. Odds ratios of smokers to non-smokers for a one standard deviation increase in the BJSQ stress Z score of men and women. (by subscales)

	Women	Men
BJSQ Subscales	OR [95%CI]	OR [95%CI]
Job Stressors		
Job demand	0.95 [0.90-1.00]	0.95 [0.92-0.97]
Job control	1.00 [0.95-1.04]	0.95 [0.93-0.98]
Meaningfulness of work	1.02 [0.97-1.08]	1.02 [0.99-1.05]
Work environment	0.96 [0.95-1.00]	0.98 [0.96-1.01]
Suitability for work	0.90 [0.86-0.95]	1.00 [0.98-1.04]
Physical burden	1.17 [1.12-1.22]	1.15 [1.13-1.18]
Skill utilization	1.06 [1.02-1.11]	0.98 [0.96-1.01]
Required job quality	0.94 [0.90-0.99]	1.02 [0.99-1.05]
Interpersonal relationship	1.09 [1.04-1.14]	1.07 [1.04-1.10]
Stress Reaction		
Vigor	1.02 [0.97-1.07]	1.03 [1.00-1.06]
Irritation	1.16 [1.11-1.22]	1.15 [1.11-1.18]
Fatigue	1.09 [1.03-1.16]	1.12 [1.08-1.16]
Anxiety	0.90 [0.85-0.95]	0.92 [0.89-0.95]
Depression	0.97 [0.91-1.32]	0.92 [0.88-0.95]
Physical symptoms	1.25 [1.19-1.32]	1.13 [1.10-1.17]
Social Support		
Superiors support	1.01 [0.96-1.06]	0.93 [0.90-0.96]
Co-workers support	0.92 [0.88-0.97]	0.85 [0.82-0.88]
Family support	1.13 [1.09-1.18]	1.12 [1.10-1.15]

(Logistic analysis adjusted by age, BMI, amount of alcohol consumed, and frequency of alcohol drinking)

Table 3. Odds ratios of smoking to not smoking for the BSJQ subscale combinations highly associated with smoking.

			OR (95%CL)	OR (95%CL)
Physical symptoms	Irritation	Physical burden	Women	men
(-)	(-)	(-)	1·00	1·00
(-)	(-)	(+)	1.36 [1.18-1.55]	1.27 [1.19-1.36]
(+)	(-)	(-)	1.47 [1.25-1.73]	1.16 [1.05-1.28]
(-)	(+)	(-)	1.53 [1.28-1.82]	1.35 [1.24-1.47]
(-)	(+)	(+)	1.73 [1.47-2.03]	1.52 [1.41-1.65]
(+)	(-)	(+)	1.93 [1.66-2.23]	1.66 [1.52-1.80]
(+)	(+)	(-)	2.06 [1.79-2.38]	1.45 [1.33-1.58]
(+)	(+)	(+)	2.63 [2.31-3.00]	1.79 [1.67-1.93]

(+): positive z-score, (-): negative z-score

Figure 1.

Z-scores of components and subscales on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity.

†: P<0.05 vs. non-smoker (Dunnett's test only), #: p<0.05 vs. non-smoker (Dunnett's test and multivariate analysis adjusted for age, BMI, amount of alcohol drinking, and frequency of alcohol drinking)

Figure 2.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, age group (≥40 y and <39y) and main industries.

†: p<0.05 vs. non-smoker (Dunnett's test only), #: p<0.05 vs. non-smoker (Dunnett's test and multivariate analysis adjusted for BMI, amount of alcohol drinking, and Frequency of alcohol drinking)

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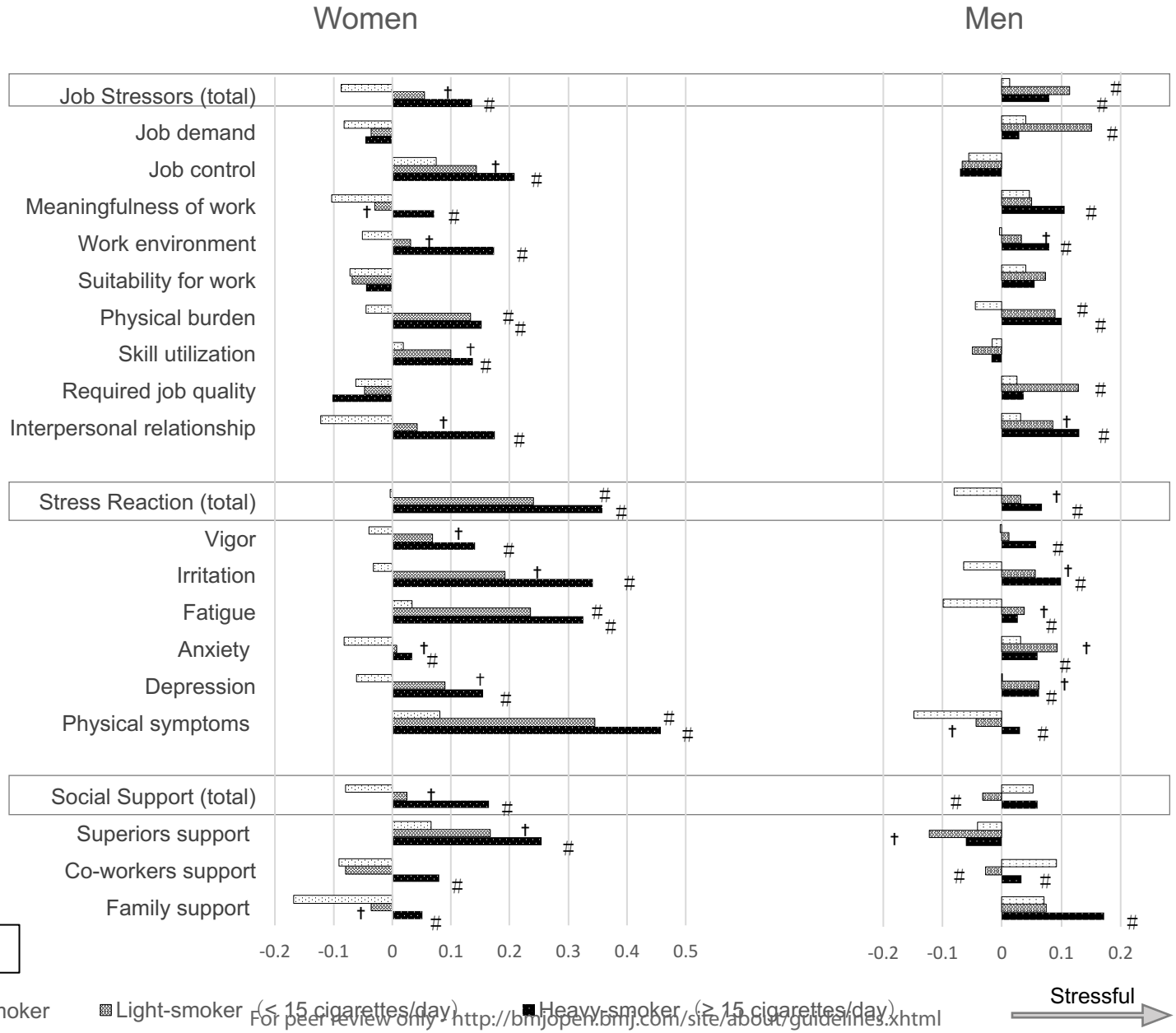

Figure1.

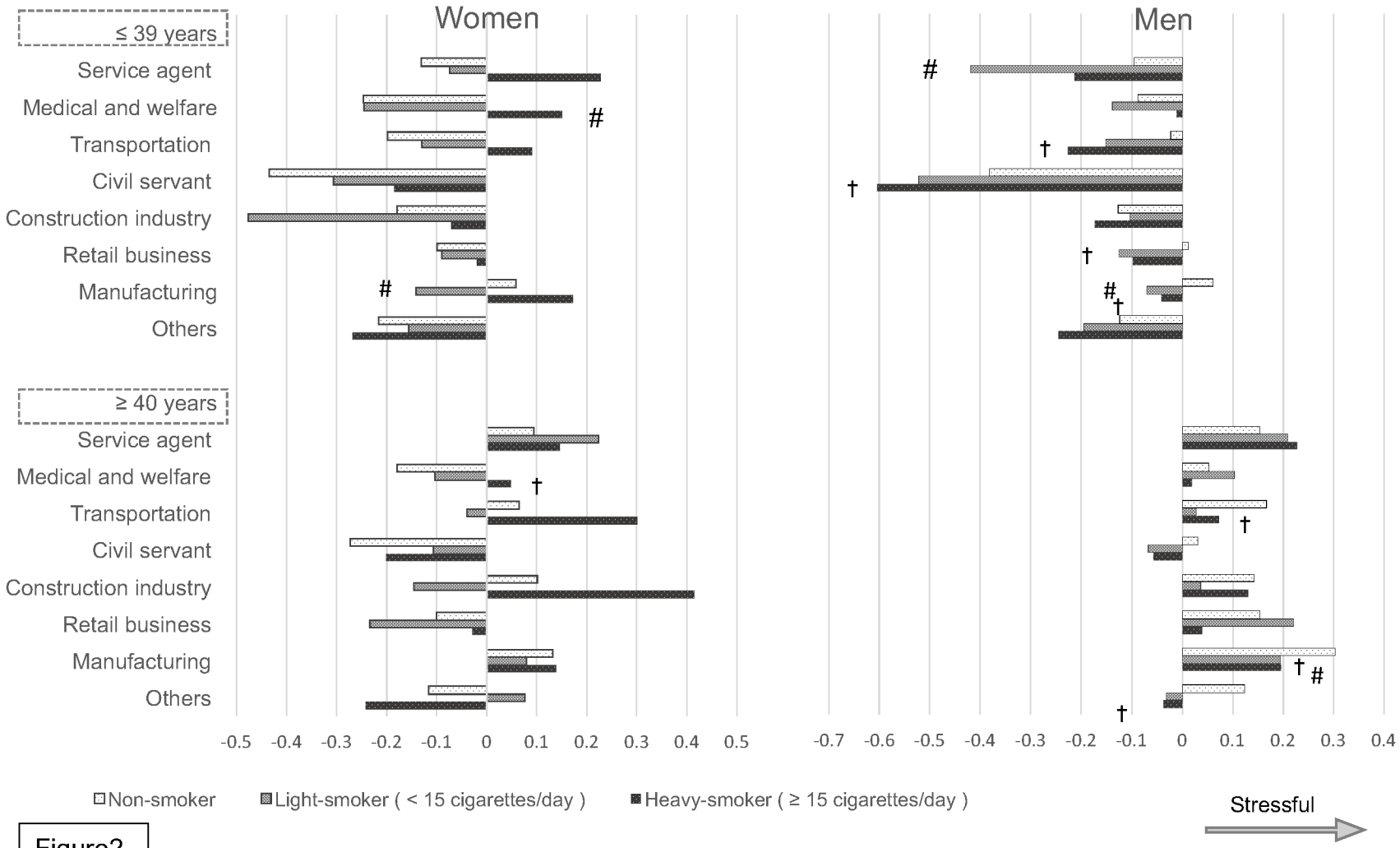
Women
Men
≤ 39 years
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
≥ 40 years
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
Non-smoker
Light-smoker (< 15 cigarettes/day)
Heavy-smoker (≥ 15 cigarettes/day)
Stressful

Figure2.

Suppl. Table 1. BJSQ simple total score by smoking intensity group: 3 components and 18 subscales [Light-smokers(LS)<15 cigarettes/day; Heavy-smokers(HS) ≥15 cigarettes/day]

BJSQ Stress components & subscales	Range of points	Women				Men			
		Non-smokers	Smokers			Non-smokers	Smokers		
			All smokers	Light-smokers	Heavy-smokers		All smokers	Light-smokers	Heavy-smokers
		average (SD)				average (SD)			
Job Stressors (total)	17-68	41.3 (6.8)	42.4 (6.9) [ac]	42.3 (6.8) [b]	42.8 (7.1) [bc]	42.0 (6.8)	42.5 (6.7) [ac]	42.7 (6.6) [b]	42.4 (6.7) [bc]
Job demands	3-12	8.0 (2.1)	8.1 (2.1) [ac]	8.1 (2.0)	8.1 (2.1)	8.3 (2.1)	8.4 (2.0) [ac]	8.5 (2.0) [bc]	8.3 (2.1)
Job control	3-12	7.8 (2.0)	8.0 (2.1) [ac]	8.0 (2.1) [b]	8.1 (2.1) [bc]	7.6 (2.0)	7.5 (2.0)	7.5 (2.0)	7.5 (2.0)
Meaningfulness of work	1-4	2.1 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.9) [bc]	2.2 (0.8)	2.3 (0.8) [ac]	2.2 (0.8)	2.3 (0.8) [bc]
Work environment	1-4	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.5 (1.0) [bc]	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.4 (1.0) [bc]
Suitability for work	1-4	2.1 (0.7)	2.1 (0.8)	2.1 (0.7)	2.1 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)
Physical burden	1-4	2.5 (1.1)	2.7 (1.1) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]	2.5 (1.0)	2.7 (1.0) [ac]	2.7 (1.0) [b]	2.7 (1.0) [bc]
Skill utilization	1-4	2.2 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.8) [bc]	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)
Required job quality	3-12	8.2 (2.0)	8.2 (2.0)	8.2 (2.0)	8.1 (2.0)	8.4 (1.9)	8.5 (1.9) [ac]	8.6 (1.9) [bc]	8.4 (1.9)
Interpersonal relationship	3-12	6.0 (1.9)	6.4 (2.0) [ac]	6.3 (2.0) [b]	6.6 (2.0) [bc]	6.3 (1.9)	6.5 (1.9) [ac]	6.4 (1.9) [b]	6.5 (1.9) [bc]
Stress Reaction (total)	29-116	57.4 (14.4)	61.5 (15.4) [ac]	61.0 (15.2) [bc]	62.7 (15.7) [bc]	56.3 (14.6)	58.3 (14.6) [ac]	57.9 (14.6) [b]	58.5 (14.6) [bc]
Vigor	3-12	8.5 (2.4)	8.8 (2.4) [ac]	8.7 (2.4) [b]	8.9 (2.4) [bc]	8.5 (2.3)	8.6 (2.2) [ac]	8.6 (2.2)	8.7 (2.2) [bc]
Irritation	3-12	6.4 (2.4)	7.1 (2.5) [ac]	6.9 (2.5) [b]	7.3 (2.5) [bc]	6.3 (2.4)	6.7 (2.4) [ac]	6.6 (2.4) [b]	6.7 (2.4) [bc]
Fatigue	3-12	6.9 (2.5)	7.4 (2.6) [ac]	7.4 (2.6) [bc]	7.6 (2.6) [bc]	6.5 (2.4)	6.9 (2.4) [ac]	6.9 (2.4) [b]	6.8 (2.4) [bc]
Anxiety	3-12	5.9 (2.3)	6.2 (2.4) [ac]	6.1 (2.3) [b]	6.2 (2.4) [bc]	6.2 (2.3)	6.3 (2.3) [ac]	6.3 (2.3) [b]	6.3 (2.3) [bc]
Depression	6-24	10.2 (3.7)	10.8 (3.9) [ac]	10.8 (3.9) [b]	11.0 (3.9) [bc]	10.4 (3.9)	10.7 (3.8) [ac]	10.7 (3.8) [b]	10.7 (3.9) [bc]
Physical symptoms	11-44	19.6 (5.5)	21.3 (6.1) [ac]	21.1 (6.1) [bc]	21.7 (6.2) [bc]	18.3 (5.6)	19.1 (5.8) [ac]	18.9 (5.8) [b]	19.3 (5.8) [bc]
Social Support (total)	9-36	19.7 (4.9)	20.4 (5.0) [ac]	20.2 (5.1) [b]	20.9 (4.9) [bc]	20.4 (5.1)	20.2 (5.1) [ac]	19.9 (5.1) [bc]	20.4 (5.2)
Superiors' support	3-12	7.9 (2.2)	8.2 (2.3) [ac]	8.1 (2.3) [b]	8.3 (2.2) [bc]	7.7 (2.2)	7.6 (2.2) [ac]	7.5 (2.2) [bc]	7.6 (2.2)
Co-workers' support	3-12	6.8 (2.1)	6.9 (2.1) [ac]	6.8 (2.2)	7.1 (2.1) [bc]	7.2 (2.0)	7.0 (2.0) [ac]	6.9 (2.1) [bc]	7.0 (2.0) [bc]
Family support	3-12	5.0 (2.0)	5.4 (2.2) [ac]	5.3 (2.2) [b]	5.5 (2·2) [bc]	5.5 (2.2)	5.7 (2.2) [ac]	5.5 (2.2)	5.7 (2.2) [bc]

[a] $p<0.05$ vs. non-smokers (unpaired t test), [b] $p<0.05$ vs. non-smokers (Dunnett's test)

[c] $p<0.05$ vs. non-smokers (multivariate analysis adjusted for age, BMI, amount of alcohol drinking, frequency of alcohol drinking)

BJSQ: Brief Job Stress Questionnaire

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4,5
Objectives	3	State specific objectives, including any prespecified hypotheses	4,5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	6,7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	8,9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8,9

		(*b*) Report category boundaries when continuous variables were categorized	8,9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8,9
Discussion			
Key results	18	Summarise key results with reference to study objectives	9,10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12,13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	9-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Differences in Occupational Stress by Smoking Intensity and Gender in Cross-sectional Study of 59,355 Japanese Employees using the Brief Job Stress Questionnaire (BJSQ); The Niigata Wellness Study

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Differences in Occupational Stress by Smoking Intensity and Gender in Cross-sectional Study of 59,355 Japanese Employees using the Brief Job Stress Questionnaire (BJSQ); The Niigata Wellness Study

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Word count: 3923

ABSTRACT

Objectives It has been hypothesized that smoking intensity may be related to occupational stress. This study aimed to investigate whether stress, including problems with superiors or co-workers, is a driver of smoking.

Methods Participants were 59,355 employees across multiple occupations who completed a self-reported questionnaire-based occupational stress survey using the Brief Job Stress Questionnaire (BJSQ). Stress scores for the BJSQ subscales were summed up after assigning high points for high stress and then converted to Z-scores based on the mean of all participants. Heavy smokers (HS) smoked ≥15 cigarettes/day and light smokers (LS) smoked <15 cigarettes/day and were compared to non-smokers (NS).

Results The main subscale items that were significantly associated with smoking status in both genders included "physical burden," "irritation," and "physical symptoms." In the analysis that included smoking intensity, the stress score for "co-workers' support" was significantly lower for LS men than NS men (NS 0.091 ± 0.98, LS -0.027 ± 1.00, HS 0.033 ± 0.99), and was significantly higher for HS women than NS women (NS -0.091 ± 1.00, LS -0.080 ± 1.05, HS 0.079 ± 1.03). However, the stress score for "co-workers' support" was low among women LS aged ≤39 years old in the manufacturing industry.

Conclusions It was speculated that LS men and some LS women gained "co-workers' support" using smoking as a communication tool while reducing the degree of smoking. The existence of such "social smokers" suggested that to promote smoking cessation, measures are essential to improve communication between workers in addition to implementing smoking restrictions in the workplace.

Strengths and limitations of this study

- The strength of this study is that it is one of the largest comprehensive surveys of more than 50000 employed individuals in East Asia and describes a wide range of components of occupational stress, including support by superiors or co-workers.

- In addition to a simple comparison of smokers and non-smokers, we compared heavy smokers and light smokers separately to clarify stress factors characteristic of women who are heavy smokers and men who are light smokers, which has not been well studied.

- We have included industry-specific surveys to clarify conditions of support by co-workers according to smoking rates in workplaces.

- A limitation of this study is that it was a cross-sectional study and therefore causal relationships could not be identified.

INTRODUCTION

Smoking is not only a personal health problem that presents a significant risk for conditions such as malignancies and cardiovascular and respiratory diseases but also is a serious public health challenge, such as workplace secondhand smoke and work productivity issues.[1-4] Most studies that include smoking and occupational stress consider both as risk factors for non-communicable diseases and unfavorable habits such as those related to alcohol drinking, overeating, and exercise. Only a few studies have focused directly on the relationship between smoking and occupational stress.[5-9] Since the serious health hazards of smoking have become recognized, the smoking rate among Japanese men has decreased year by year, although it is still high worldwide and the smoking rate among women remains flat.[10, 11] Under these circumstances, the revised Health Promotion Law was fully enforced in Japan in 2020. This law stipulates that "premises of public facilities such as hospitals and schools are non-smoking, commercial and industrial facilities such as offices and restaurants are non-smoking in principle, and in case of violations, a penalty of 500,000 yen or less" will be enforced. However, in existing small-scale restaurants or bars, smoking bans are not enforced, and exceptions are allowed as a transitional measure, which makes this a slightly loose regulation.[12]

Research on the backgrounds of smokers in Japan has been reported in recent years, mainly on educational disparities [13, 14] and industry differences. [15] Although there are few academic studies published in English addressing why Japanese workers continue to smoke or why they are unable to quit, in general, many smokers cite "stress" as a reason. [16, 17] Although it was not a study of reasons for smoking, a recent Japanese survey of the general public that included those who were not working reported an association between smoking intensity and ‘serious psychological distress’ in women. [18] In addition, a market research company (Cross Marketing Inc. Tokyo.

Japan) [19] conducted a survey on reasons for smoking and found that "stress" was cited by 40.4% of smokers as the main reason for smoking in Japan.

There are multiple aspects to occupational stress, and various stress models have been developed to elucidate causal associations with occupational stress. Among them, workload (job demand) and work discretion (job control) are widely accepted as representative causes.[20] [21] In addition, workplace relationships are important as a buffer against stress. The demand-control-support (DCS) model, which adds support from co-workers and supervisors to demand and control, is mainly used to investigate the association between cardiovascular disease and work stress in research. [22, 23] In recent years, not only the DCS model but also indicators such as workplace social capital or organizational justice have been used to investigate workplace support, but the relationship between smoking and these stress indicators is still controversial.

For example, Kouvonen and colleagues reported that lower “job control” was associated with increased smoking intensity among women civil servant in Finland while no such association was found in men.[7] In a study of Japanese men in a single workplace, Kawakami and colleagues suggested that the intensity of smoking increased in Japanese men in a group with low job control and low social support.[8] Fukuoka et al. tracked the outcome of smoking cessation for two years and reported no association between stressors and continued smoking cessation in a similar group of Japanese male workers. [24] Studies using other indicators also found that "low confidence in workplace organizations" was associated with smoking,[9] and "poor trust relationship with superiors" was associated with smoking in women managers.[5] On the other hand, the opposite result was reported where "good workplace support" was associated with smoking among women in the nursing profession.[25] Although has been reported that "social connections" are involved in both smoking and smoking cessation,[26] other conditions, such as related to workplace environment or duties, might be required for social support to help control smoking.

Because of the very limited number of large-scale comprehensive studies on a variety of industries in the East Asian region, where smoking rates are known to be high, no consistent conclusions can be drawn on the association between various occupational stresses, such as lack of workplace support, and smoking. Therefore, we administered a detailed occupational stress survey, including smoking intensity and workplace support, to approximately 60,000 employees from industries of different sizes and categories to determine the relationship between smoking intensity and occupational stress and differences in the relationship by gender, age, and industry.

We hypothesized that smokers experience more occupational stressors than non-smokers, and that the greater the stress, the higher the intensity of smoking. We also hypothesized that better workplace support would buffer stress and suppress smoking. To test these hypotheses, we compared the stress scale of non-smokers, light smokers, and heavy smokers by gender. Since supportive environments in the workplace vary according to the age of workers and industry, we added comparisons by age group and industry group. Therefore, through our results we could identify measures to promote smoking cessation by reducing working smokers' stress and improving the work environment.

METHODS

Survey participants

Among 64,279 employees who underwent an occupational health examination and stress check based on the Occupational Safety and Health Act between Apr. 2016-Mar. 2017 in Niigata Prefecture, 34,865 men (mean age 41.8 years old) and 24,490 women (mean age 41.9 years old) participated in this study. Excluded were employees whose gender was unknown, had incomplete examination data, an incomplete stress check response, or were ≤19 years old or ≥70 years old. The industry type was classified

according to a large number of persons working at seven occupations and a smaller number of workers in an eighth category designated as "other".

Also, in this survey participants were limited to workers at establishments in and around Niigata Prefecture; thus, participants were not representative of workers nationwide.

Patient and Public Involvement

Patients were not involved in this study.

Stress check

The 57-item “Brief Job Stress Questionnaire” (BJSQ) developed and validated by Shimomitsu and colleagues was used to assess occupational stress.[27] It has been used in previous studies as well as in workplaces across the country by the Ministry of Health, Labour and Welfare in guiding the Stress Check Program.[28] The purpose of this program was to assess stress in individual workers and in the work environment, and its results were reported to be associated with long-term leave and turnover of workers. [29, 30] Participants were required to answer questions on the BJSQ using a Likert scale of one to four points. The BJSQ contains several related questions, and the scores of the individual questions are added together to produce a result for each category. The total score for each category resulted in high points for high stress (simple total score). Question content was broadly divided into three components: "Job Stressors," "Mental and Psychological Stress Reactions (“Stress Reaction”) ", and "Social Support." "Job Stressors" has nine subscales (job demands, job control, meaningfulness of work, work environment, suitability for work, physical burden, skill utilization, required job quality, interpersonal relationships), and “Stress Reaction” has six subscales (vigor, irritation, fatigue, anxiety, depression, physical symptoms). Originally, "Social Support" included four subscales (superiors, co-workers, family and/or friends (family), life satisfaction), but “life satisfaction” was excluded because it

was not related to support resources. Its elimination left three subscales. Scores were tabulated for each of these three components and 18 subscales.

These simple total scores were compared and examined using z-score values (z-scores) standardized from the average score of participants for each component or each subscale. Results with reference to the simple total scores are presented in Suppl. Table 1.

Smoking status and intensity

Information on smoking status (smokers or non-smokers) and the number of cigarettes smoked per day was obtained from the medical checkup questionnaire. Based on the median number of cigarettes smoked in the all smokers (AS) group, we defined those who smoked <15 cigarettes/day as light smokers (LS) and those who smoked ≥15 as heavy smokers (HS). In the LS, HS, and non-smoker (NS) groups, the distribution of chronological age was calculated in ten-year increments and the stress check scores (z-scores) were compared among the three groups.

Analysis of "Co-workers' support" by industry type and workers' age

To investigate differences by industry and age, we divided the participants into two age groups (≥40 years old or ≤39 years old) and compared the "co-workers' support" subscale by industry categories.

Statistical analysis

Smoking was compared between the AS and NS groups using unpaired t-tests for all 18 subscales, and additionally compared using nominal logistic analysis adjusted for age, body mass index (BMI), amount of alcohol consumption, and drinking frequency.

Based on the results obtained from the basic statistics, the average age and BMI differed significantly according to smoking intensity. Therefore, age and BMI were selected as

items for adjustment. In addition, since a prior publication [31] showed that many workers smoke when drinking, drinking behavior was also an adjustment item. To clarify the synergy of stress indicators that are strongly related to smoking status, we selected the top three subscales according to odds ratios. Participants with positive or zero Z-scores on the selected subscales were classified as stressed (+) and those with negative Z-scores were classified as stressed (-) to form two groups. Nominal logistic regression analysis was performed on eight combinations of three subscale stresses (+) or (-), adjusting for age, BMI, amount of alcohol consumption, and frequency of drinking.

Regarding smoking intensity, the Z-scores of the three components of the BSJQ and the 18 subscales were compared for the NS, LS, and HS groups by the Dunnett test with NS as the control. Z-scores were examined by multivariate analysis adjusted for age and BMI, amount of alcohol consumption, and drinking frequency. Additionally, an examination of "co-workers' support" by industry and age group compared the NS, LS, and HS groups by multivariate analyses adjusted for BMI, amount of alcohol consumption, and drinking frequency.

JMP for Macintosh (14.0.0) was used for statistics.

Ethical Considerations

The study was approved by the Ethics Committee of Niigata University [2017-0401], and we have obtained consent for the use of personal information from all participants on the health checkup. After confirming the concordance of the data, personal information such as the participant's name, personal identification code for health checkup orders, and the name of the company or office to which the worker belonged was removed before using the data for analysis.

This study does not involve animal subjects.

RESULTS

The smoking rate for the entire study population was 13.6% for women and 41.4% for men. For both genders, the smoking rate by age group was highest in the 40s and the lowest in the 20s. There were more LS and fewer HS among women in all age groups. In men, the number of LS was greatest among those in their 20s. The industry category with the lowest smoking rate was civil servants of both genders (Table 1).

Mean age of women smokers was significantly older than for NS; in addition, both LS and HS women were significantly older than NS women. Among men, LS were significantly younger than NS, and HS were significantly older than NS. In women, BMI was significantly lower in LS and higher in HS than in NS, but no significant difference was observed between NS and AS. In men, BMI was significantly lower in AS and LS than in NS, but there was no significant difference in BMI between HS and NS (Table 1).

As shown in Table 2, many of the stress subscales were independently and significantly associated with smoking, but the three highest odds ratios for both genders were for "physical burden," "irritation," and "physical symptoms." Conversely, “co-workers’ support” had the lowest odds ratio of all subscales, especially for men. The risk increased with the combination of the three factors of “physical burden,” “irritation,” and “physical symptoms” for both genders (Table 3).

Compared with NS, the BJSQ simple total score for women AS had significantly higher stress values than for NS in all components (Suppl. Table 1). When compared to NS by smoking intensity (Fig. 1), Z-scores for almost all subscales for women HS were significantly higher, with only "job demands," "suitability for work," and "required job quality" being not significantly different between NS and HS. Results of the multivariate analysis for all “Social Support” subscales also showed that HS women had significantly higher Z-score values than NS women.

In men, the AS group had slightly but significantly lower scores for “Social Support” than the NS group (Suppl. Table 1). According to smoking intensity, the “Social Support” score compared with NS was significantly lower in LS by multivariate analysis, but no statistical difference was observed between NS and HS (Fig. 1). Significantly higher stress scores were shown for "job demands" and "required job quality" in LS than in NS.

Since “co-workers’ support” differed from the other subscales in that smokers were less stressed than NS, we added an analysis that included industry type and chronological age (≤39 years old vs. ≥40 years old) (Fig. 2). By industry, in women, HS in the medical and welfare industry had the highest stress scores for “co-workers’ support” compared to NS in the same industry. Exceptionally, LS in the manufacturing industry were characterized by lower stress scores for “co-workers’ support” than NS. In men, LS in the service industry, LS and HS in the manufacturing industry, and HS in ‘other’ industries had significantly lower stress scores for “co-workers’ support” than NS in their respective industries. (Supplementary Figure 1) By age group, in women both HS ≥40 years old and HS ≤39 years old had the highest stress scores for “co-workers’ support” compared to NS in their respective age group. In men, HS ≥40 years old, HS ≤39 years old and LS ≤39 years old were characterized by lower stress scores for “co-workers’ support” than NS in their respective age group. (Supplementary Figure 2) By age group and industry, in women ≤39 years old, HS in the medical and welfare industry had the highest stress scores for “co-workers’ support” compared to NS in the same industry. LS in the manufacturing industry had lower stress scores for “co-workers’ support” than NS in the same industry. In men of ≤39 years old, LS in the service industry and LS in the manufacturing industry had significantly lower stress scores for “co-workers’ support” than NS in their respective industries. Also, in men ≥40 years old, HS in the manufacturing industry had significantly lower stress scores for “co-workers’ support” than NS in that industry. (Figure 2)

DISCUSSION

This is the first large-scale study to investigate a wide range of components of occupational stress and smoking intensity using the BSJQ. We have clarified occupational stress specific to smokers on the following three points. (1) Subscales independently associated with smoking in both genders were "physical burden", "irritation" and "physical symptoms". However, since there was no synergistic effect of these three major stress subscales, so we felt it was not important to prioritize addressing these stressor or stress response in the workplace. (2) Women HS were generally highly stressed. (3) Men LS obtained more "co-workers' support" even though they had higher stressors such as "job demands." As hypothesized, the larger the amount of smoking in women, the greater the stress in all three components of "Job Stressors", "Stress Reactions", and "Social Support". But in men, smoking intensity and social support did not support the hypothesis. The reason why smoking status was strongly associated with "physical burden" rather than "job demands" is that "small breaks to rest the body" may be strongly linked to smoking and become a habit in the manufacturing, transport, and construction industries in men. The high rate of smoking in these occupations was already been shown in a survey of medium- and small-sized companies in Japan.[15] "Job demands" primarily identifies the degree of psychological burden whereas "physical burden" was evaluated by only one question asking whether the work involved physical labor. In an earlier occupation-specific survey, Strickland and colleagues reported nearly twice the rate of smoking among white construction workers compared with whites in general in Missouri, USA.[32] Chau and colleagues examined work content in assessing "physical job demands" and reported that workers with a higher total amount of physical work, such as "working under bad weather" and "using vibration tools," smoked greater numbers of cigarettes in the Lorene region of France.[33] This is probably because such workers often work on the same team and

recognize smoking as a “means of dealing with work difficulties.” Furthermore, smokers recognize that smoking can relieve the "irritation" that they feel as occupational stress, but this "irritation" can also occur as symptoms of nicotine withdrawal due to a temporary interruption of smoking during work.[34] In addition, nicotine withdrawal can be manifested by dizziness and palpitations**.** Parrott in a review stated that smokers tended to report high “daily” stress and that stress symptoms such as irritation increase when they cannot smoke frequently, and that successful quitters experience reduced “stress.”[35] Strictly speaking, these complaints by smokers may not be "physical symptoms" of occupational stress.

The reasons why women HS were highly stressed are complex. Women HS generally have high scores for "Job Stressors" such as "job control," "work environment," and "interpersonal relationships," and they may be engaged in low discretionary tasks in the first place. In addition, it was shown that women smokers not only workers in general were more likely than men to express negative emotions, such as anxiety, regarding the stress response;[36] biological and socio-environmental ‘sex differences’ are being explored.[37] Tomioka et al. [18] suggested the necessity of coping with psychological distress as a smoking cessation measure for Japanese women, including the non-regularly employed and unemployed. Our results suggest that coping with stress symptoms may also be useful for smoking cessation among regularly employed women who are more financially stable. Similarly, the results of "Social Support" suggested that women HS engaged in tasks with less support than NS. Conversely, the stress caused by lack of social support may have led women to smoke. Creswell and colleagues reported that in general "social support" aided in the success of smoking cessation.[38]

In men, there might be a kind of “social smoking” because smokers reported better “Social Support” than non-smokers. Earlier reports captured the phenomenon that college student smokers smoked only when with friends and acquaintances,[39, 40] and

the presence of youth who habitually smoked only on social occasions, such as at parties, became recognized. They were reported to display positive actions in preventing secondhand smoking by non-smokers.[41] Even in Japan, smokers who "do not smoke at home" exist, and their restrained smoking style was reported.[42] This type of smoking, which is highly related to peers, has been defined as "peer smoking".[33, 43] The results for "co-worker's support" suggest that LS are more likely to be social smokers, especially in the service and manufacturing industries. Not only men, but also women LS in the manufacturing industry had significantly better co-workers' support than NS. This means that LS in these industries may feel closer to their co-workers when they smoke.

Research on social support and smoking in the workplace suggested that smoking functioned as a communication tool. In China, where the smoking rate is as high as 38%, it is highly speculated that supervisors and co-workers are smokers, so smokers are more likely to obtain support by supervisors.[44] A study in North America reported (smoking rate: 26%), that supervisors' support inhibited smoking, but co-workers' support did not.[45] In addition, a study of Brazilian civil servant men (smoking rate: 17%) reported that social support suppressed smoking.[46] Thus, the association between "social support" and smoking may be explained by differences in the workplace smoking rate, with better relationships between non-smokers in environments with a low smoking rate and better communication between smokers in workplaces with high smoking rates. Men LS probably have sufficient knowledge about the health hazards of smoking to suppress their smoking intensity. However, they may be psychologically unable or fail to initiate smoking cessation because they may be afraid of losing social support in a workplace with a high smoking rate. Indeed, interventional surveys of smoking cessation guidance have reported that workplaces with a higher percentage of smokers have a stronger impact on peer smoking behavior and lower rates of long-term smoking cessation.[43]

Smoking rates may also be a factor in "co-workers' support" scores. Among women, "co-workers' support" was better for LS than NS in the manufacturing industry. The smoking rate among women in the manufacturing industry was relatively high at 15.8%, and it is estimated that women obtain "co-workers' support" through smoking in such workplaces. These findings seemed to mean that good communication through smoking in a workplace could occur if the smoking rate was relatively high. In addition, the relationship between co-worker support and smoking intensity within industries may differ depending on work duties. In health and social work, smoking is perceived as undesirable, and HS who take frequent smoking breaks are imagined to have reduced communication with colleagues. Promoting smoking cessation among youth is desirable for their health, and smoking regulations may be acceptable especially for young social smokers due to their behavioral characteristics. Common social smoking measures in workplaces include bans on smoking on workplace premises and during working hours.[47] Simultaneously, it is necessary to promote communication among workers in the workplace, even under a non-smoking environment. Alternatives to smoking that promote informal communication include taking short breaks, increasing opportunities for face-to-face conversations, and increasing opportunities for interaction with workers in other departments based on the benefits that smokers have received. [48]

Significance and limitations of this study

The strength of this study is that it was a large comprehensive occupational stress survey of employed individuals in East Asia. Therefore, this study could investigate the association between a wide range of occupational stresses and smoking intensity across multiple occupations, suggesting for the first time that workplace stressors and supportive conditions may differ according to smoking rates in workplaces and by gender.

A limitation of this study is that it was cross-sectional and therefore causal relationships could not be identified. Factors such as working hours, job position, and company size, which could not be surveyed at this time, may have contributed to the association between smoking and physical burden. Also, because the number of cigarettes smoked was provided by self-report in a health checkup questionnaire, responses may be inaccurate, such as inputting less than the actual dose. Reports by users of electronic cigarettes and heated tobacco products users may not have been accurate because it is difficult to translate these products into the number of cigarettes smoked or because users are not aware of them as tobacco products.

CONCLUSIONS

The occupational stress of smokers of both genders may be related to the subjective "physical burden," "irritation," and "physical symptoms." In analyses of smoking intensity and gender, both strong psychosomatic stress symptoms such as "irritation" and "physical symptoms" and lack of social support at work were observed in women HS; however, in contrast, over all smokers' “co-workers’ support” was good in men. In addition, in young women LS in the manufacturing industries, where the smoking rate is relatively high, we observed significantly better “co-workers’ support” compared to that in NS, suggesting the presence of "social smokers" who continue to smoke small amounts as a communication tool in these workplaces.

These results suggest that improvement of the communication environment among workers may be essential for the promotion of smoking cessation at the same time as smoking bans in worksites and public facilities.

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Contributorship statement

ST, KK, and HS planned and designed the study. MT, KM, MO, and KS did project administration, funding acquisition and data collection. ST and KK calculated data for the statistical analyses, did the literature review and wrote the first draft of the manuscript following discussion with all authors, MK, AK, KF, and HS contributed to the editing of the manuscript. All authors participated in data interpretation, commented on subsequent drafts, approved the final manuscript, and agreed to submit the manuscript for publication.

Declaration of interests

The authors declare no conflict of interest.

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Data sharing statements

No additional data available.

Table 1. Demographics of Study Participants (n=59,355)

Participants	Women					Men				
Smoking status		Non-smokers	Smokers				Non-smokers	Smokers		
			All smokers					All smokers		
smoking intensity				Light smokers	Heavy smokers				Light smokers	Heavy smokers
Average (SD)										
Age [y]	41.9 (12.2)	41.7 (12.4)	43.3 (10.6) [a]	43.0 (10.9) [b]	44.2 (9.8) [b]	41.8 (12.5)	41.4 (13.0)	42.3 (11.8) [a]	38.5 (12.0) [b]	44.4 (11.2) [b]
BMI [kg/m^2]	21.76 (3.90)	21.77 (3.89)	21.71 (3.98)	21.55 (3.84) [b]	22.09 (4.26) [b]	23.20 (3.72)	23.29 (3.76)	23.08 (3.68) [a]	22.70 (3.60) [b]	23.29 (3.71)
Total Participants										
n <smoking rate %>	24,490	21,148	3,342 <13.6>	2327 < 9.5>	1015 < 4.1>	34,865	20,438	14,427 <41.4>	5219 <15.0>	9208 <26.4>
Age group (y)										
20-29	4,936	4,544	392 < 7.9>	313 < 6.3>	79 <1.6>	7,068	4,698	2,370 <33.5>	1404 <19.9>	966 <13.7>
30-39	5,771	4,958	813 <14.1>	575 <10.0>	238 <4.1>	9,050	5,100	3,951 <43.7>	1658 <18.3>	2292 <25.3>
40-49	6,293	5,150	1,143 <18.2>	743 <11.8>	400 <6.4>	8,404	4,561	3,843 <45.7>	1085 <12.9>	2758 <32.8>
50-59	5,537	4,746	791 <14.3>	558 <10.1>	233 <4.2>	6,756	3,762	2,994 <44.3>	733 <10.8>	2261 <33.5>
60-69	1,953	1,750	203 <10.4>	138 < 7.1>	65 <3.3>	3,587	2,317	1,270 <35.4>	339 <9.5>	931 <25.9>
Industry category										
Service agent	1,368	1,157	211 <15.4>	145 <10.6>	66 <4.8>	2,329	1,296	1,033 <44.4>	346 <14.9>	687 <29.5>
Medical and welfare	5,121	4,424	697 <13.6>	511 <10.0>	186 <3.6>	1,907	1,205	702 <36.8>	365 <19.1>	337 <17.7>
Transportation	774	641	133 <17.2>	85 <11.0>	48 <6.2>	4,354	2,240	2,114 <48.6>	416 < 9.6>	1698 <39.0>
Civil servant	3,355	3,178	177 < 5.3>	137 < 4.1>	40 <1.2>	2,299	1,651	648 <28.2>	277 <12.0>	371 <16.1>
Construction industry	366	314	52 <14.2>	34 < 9.3>	18 <4.9>	2,072	1,010	1,062 <51.3>	227 <11.0>	835 <40.3>
Retail business	3,639	3,040	599 <16.5>	405 <11.1>	194 <5.3>	3,632	2,212	1,420 <39.1>	566 <15.6>	854 <23.5>
Manufacturing	8,396	7,070	1,326 <15.8>	906 <10.8>	420 <5.0>	15,689	9,183	6,506 <41.5>	2674 <17.0>	3832 <24.4>
Other	1,471	1,324	147 <10.0>	104 < 7.0>	43 <2.9>	2,583	1,641	942 <36.5>	348 <13.5>	594 <23.0>
Alcohol consumption										
Amount (drinks/day)										
-2.2	18,470	16,481	1,989	1,419	570	17,064	10,947	6,117	2,333	3,784
2.3-4.4	4,511	3,614	897	639	258	11,398	6,233	5,165	1,889	3,276
4.5-6.6	1,212	867	345	209	136	4,807	2,447	2,360	733	1,627
6.7-	297	186	111	60	51	1,596	811	785	264	521
Frequency										
rarely	12,528	11,220	1,308	906	402	10,717	6,996	3,721	1,331	2,390
occasionally	8,533	7,501	1,032	760	272	12,042	7,446	4,596	2,062	2,534
everyday	3,429	2,427	1,002	661	341	12,106	5,996	6,110	1,826	4,284

[a] $p<0.05$ vs. non-smokers (unpaired t test), [b] $p<0.05$ vs. non-smoker (Dunnett's test)

[Light smokers <15 cigarettes/day; Heavy smokers ≥15 cigarettes/day; SD: standard deviation; BMI: body mass index; y: years old]

Table 2. Odds ratios of smokers to non-smokers for a one standard deviation increase in the BJSQ stress Z score of men and women. (by subscales)

	Women	Men
BJSQ Subscales	OR [95%CI]	OR [95%CI]
Job Stressors		
Job demand	0.95 [0.90-1.00]	0.95 [0.92-0.97]
Job control	1.00 [0.95-1.04]	0.95 [0.93-0.98]
Meaningfulness of work	1.02 [0.97-1.08]	1.02 [0.99-1.05]
Work environment	0.96 [0.95-1.00]	0.98 [0.96-1.01]
Suitability for work	0.90 [0.86-0.95]	1.00 [0.98-1.04]
Physical burden	1.17 [1.12-1.22]	1.15 [1.13-1.18]
Skill utilization	1.06 [1.02-1.11]	0.98 [0.96-1.01]
Required job quality	0.94 [0.90-0.99]	1.02 [0.99-1.05]
Interpersonal relationship	1.09 [1.04-1.14]	1.07 [1.04-1.10]
Stress Reaction		
Vigor	1.02 [0.97-1.07]	1.03 [1.00-1.06]
Irritation	1.16 [1.11-1.22]	1.15 [1.11-1.18]
Fatigue	1.09 [1.03-1.16]	1.12 [1.08-1.16]
Anxiety	0.90 [0.85-0.95]	0.92 [0.89-0.95]
Depression	0.97 [0.91-1.32]	0.92 [0.88-0.95]
Physical symptoms	1.25 [1.19-1.32]	1.13 [1.10-1.17]
Social Support		
Superiors support	1.01 [0.96-1.06]	0.93 [0.90-0.96]
Co-workers support	0.92 [0.88-0.97]	0.85 [0.82-0.88]
Family support	1.13 [1.09-1.18]	1.12 [1.10-1.15]

(Logistic analysis adjusted by age, body mass index, amount of alcohol consumption, and frequency of alcohol drinking)

Table 3. Odds ratios of smoking to not smoking for the BSJQ subscale combinations highly associated with smoking.

			OR (95%CL)	OR (95%CL)
Physical symptoms	Irritation	Physical burden	Women	Men
(-)	(-)	(-)	1.00	1.00
(-)	(-)	(+)	1.36 [1.18-1.55]	1.27 [1.19-1.36]
(+)	(-)	(-)	1.47 [1.25-1.73]	1.16 [1.05-1.28]
(-)	(+)	(-)	1.53 [1.28-1.82]	1.35 [1.24-1.47]
(-)	(+)	(+)	1.73 [1.47-2.03]	1.52 [1.41-1.65]
(+)	(-)	(+)	1.93 [1.66-2.23]	1.66 [1.52-1.80]
(+)	(+)	(-)	2.06 [1.79-2.38]	1.45 [1.33-1.58]
(+)	(+)	(+)	2.63 [2.31-3.00]	1.79 [1.67-1.93]

(+): positive z-score, (-): negative z-score

Figure 1.

Z-scores of components and subscales on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity.

†: P<0.05 vs. non-smoker (Dunnett's test only), #: p<0.05 vs. non-smoker (Dunnett's test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol drinking)

Figure 2.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, age group (≥40 y and ≤39 y) and main industries.

†: p<0.05 vs. non-smoker (Dunnett's test only), #: p<0.05 vs. non-smoker (Dunnett's test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and Frequency of alcohol drinking)

y: years old

Supplemental Figure 1.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity and main industries.

†: $p<0.05$ vs. non-smoker (Dunnett's test only), #: $p<0.05$ vs. non-smoker (Dunnett's test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol drinking)

Supplemental Figure 2.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, age group (≥40 y and ≤39 y)

†: $p<0.05$ vs. non-smoker (Dunnett's test only),

#: $p<0.05$ vs. non-smoker (Dunnett's test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and frequency of alcohol drinking)

y: years old

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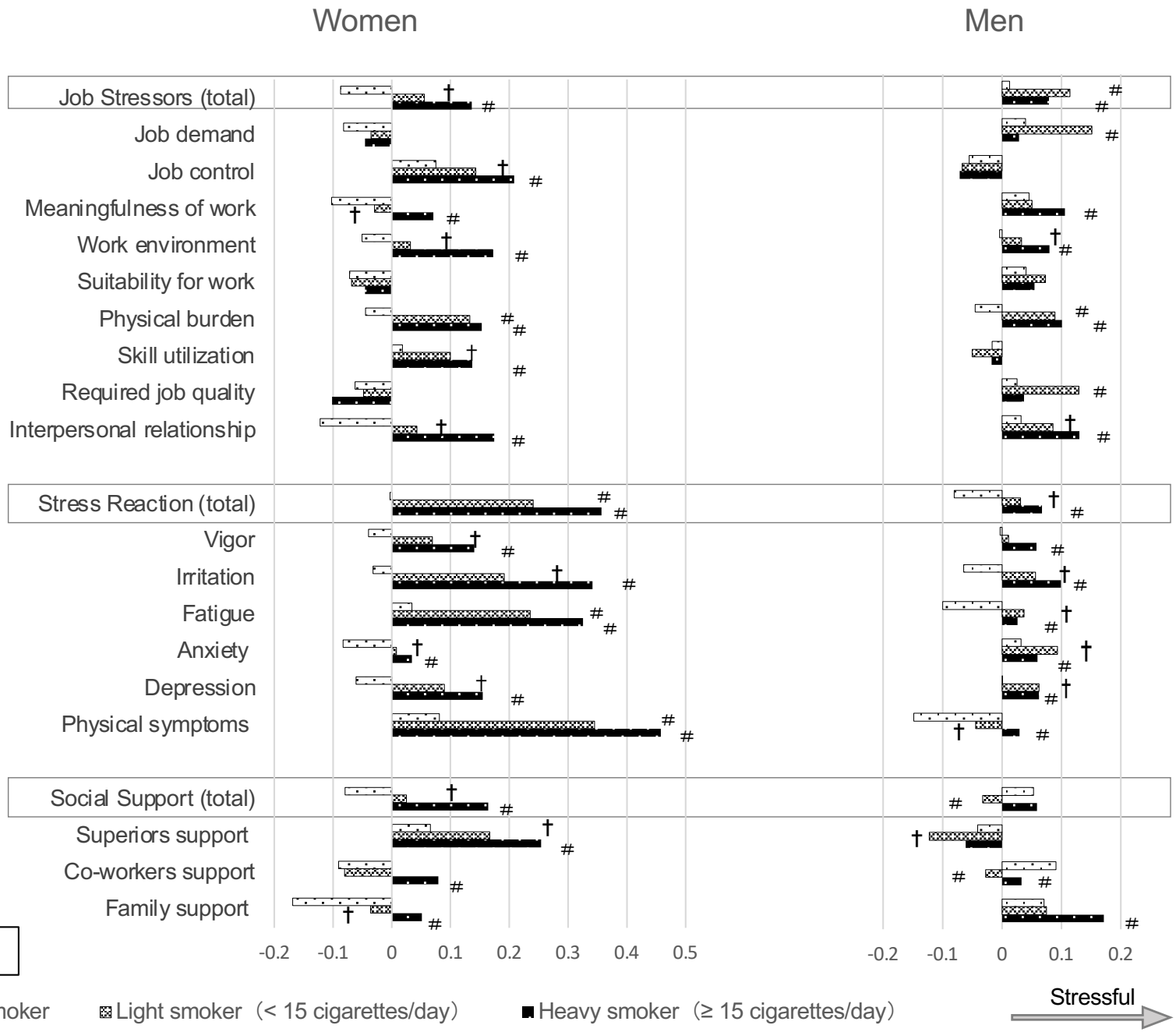

Women
Men
Job Stressors (total)
Job demand
Job control
Meaningfulness of work
Work environment
Suitability for work
Physical burden
Skill utilization
Required job quality
Interpersonal relationship
Stress Reaction (total)
Vigor
Irritation
Fatigue
Anxiety
Depression
Physical symptoms
Social Support (total)
Superiors support
Co-workers support
Family support
-0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
-0.2 -0.1 0 0.1 0.2
Non-smoker
Light smoker（< 15 cigarettes/day）
Heavy smoker（≥ 15 cigarettes/day）
Stressful

Figure1.

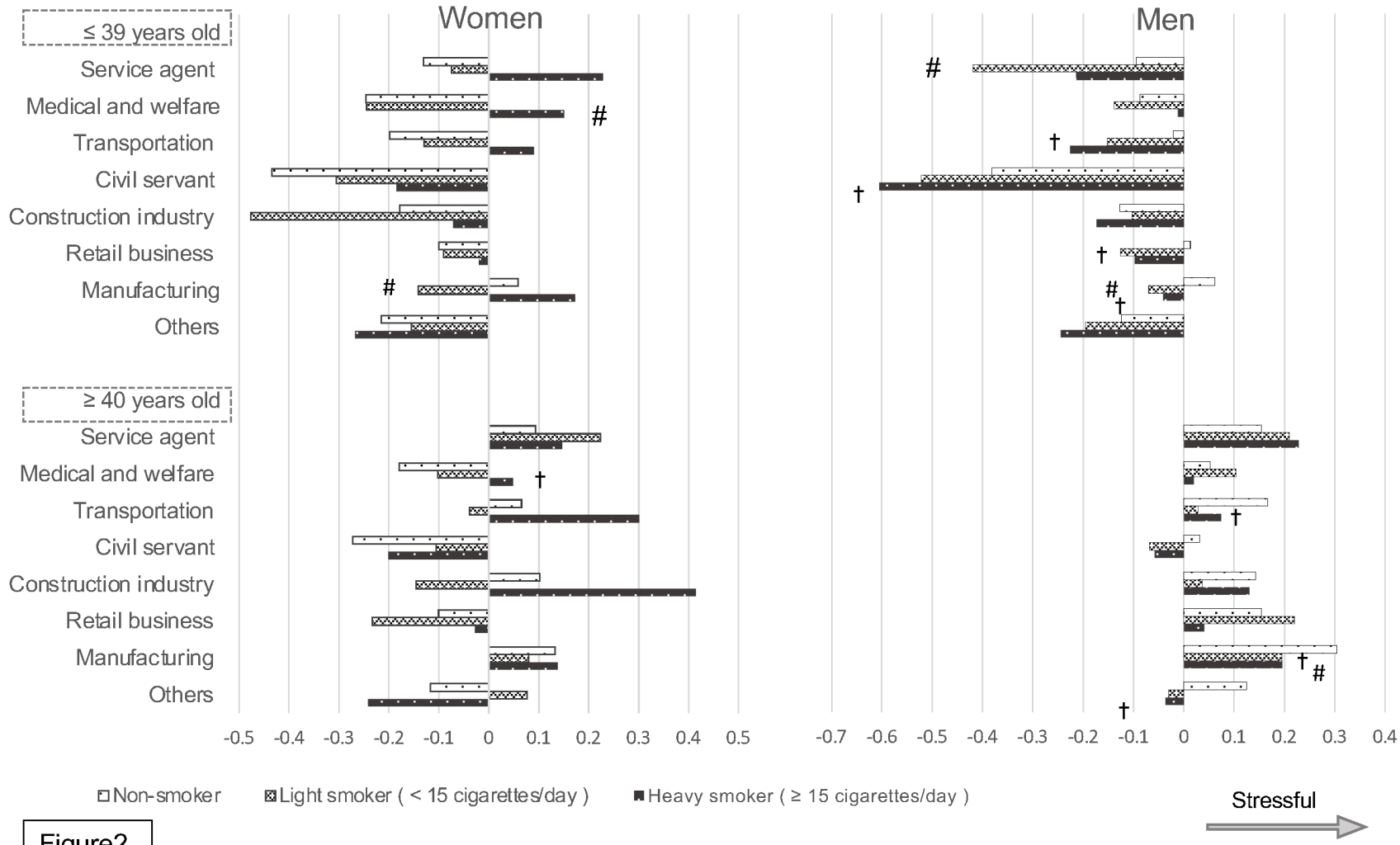

Women
Men
≤ 39 years old
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
≥ 40 years old
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
Non-smoker
Light smoker (< 15 cigarettes/day)
Heavy smoker (≥ 15 cigarettes/day)
Stressful

Figure2.

Suppl. Table 1. BJSQ simple total score by smoking intensity group: 3 components and 18 subscales

BJSQ Stress components & subscales	Range of points	Women				Men			
		Non-smokers	Smokers			Non-smokers	Smokers		
			All smokers	Light smokers	Heavy smokers		All smokers	Light smokers	Heavy smokers
		average (SD)				average (SD)			
Job Stressors (total)	17-68	41.3 (6.8)	42.4 (6.9) [ac]	42.3 (6.8) [b]	42.8 (7.1) [bc]	42.0 (6.8)	42.5 (6.7) [ac]	42.7 (6.6) [b]	42.4 (6.7) [bc]
Job demands	3-12	8.0 (2.1)	8.1 (2.1) [ac]	8.1 (2.0)	8.1 (2.1)	8.3 (2.1)	8.4 (2.0) [ac]	8.5 (2.0) [bc]	8.3 (2.1)
Job control	3-12	7.8 (2.0)	8.0 (2.1) [ac]	8.0 (2.1) [b]	8.1 (2.1) [bc]	7.6 (2.0)	7.5 (2.0)	7.5 (2.0)	7.5 (2.0)
Meaningfulness of work	1-4	2.1 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.9) [bc]	2.2 (0.8)	2.3 (0.8) [ac]	2.2 (0.8)	2.3 (0.8) [bc]
Work environment	1-4	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.5 (1.0) [bc]	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.4 (1.0) [bc]
Suitability for work	1-4	2.1 (0.7)	2.1 (0.8)	2.1 (0.7)	2.1 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)
Physical burden	1-4	2.5 (1.1)	2.7 (1.1) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]	2.5 (1.0)	2.7 (1.0) [ac]	2.7 (1.0) [b]	2.7 (1.0) [bc]
Skill utilization	1-4	2.2 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.8) [bc]	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)
Required job quality	3-12	8.2 (2.0)	8.2 (2.0)	8.2 (2.0)	8.1 (2.0)	8.4 (1.9)	8.5 (1.9) [ac]	8.6 (1.9) [bc]	8.4 (1.9)
Interpersonal relationship	3-12	6.0 (1.9)	6.4 (2.0) [ac]	6.3 (2.0) [b]	6.6 (2.0) [bc]	6.3 (1.9)	6.5 (1.9) [ac]	6.4 (1.9) [b]	6.5 (1.9) [bc]
Stress Reaction (total)	29-116	57.4 (14.4)	61.5 (15.4) [ac]	61.0 (15.2) [bc]	62.7 (15.7) [bc]	56.3 (14.6)	58.3 (14.6) [ac]	57.9 (14.6) [b]	58.5 (14.6) [bc]
Vigor	3-12	8.5 (2.4)	8.8 (2.4) [ac]	8.7 (2.4) [b]	8.9 (2.4) [bc]	8.5 (2.3)	8.6 (2.2) [ac]	8.6 (2.2)	8.7 (2.2) [bc]
Irritation	3-12	6.4 (2.4)	7.1 (2.5) [ac]	6.9 (2.5) [b]	7.3 (2.5) [bc]	6.3 (2.4)	6.7 (2.4) [ac]	6.6 (2.4) [b]	6.7 (2.4) [bc]
Fatigue	3-12	6.9 (2.5)	7.4 (2.6) [ac]	7.4 (2.6) [bc]	7.6 (2.6) [bc]	6.5 (2.4)	6.9 (2.4) [ac]	6.9 (2.4) [b]	6.8 (2.4) [bc]
Anxiety	3-12	5.9 (2.3)	6.2 (2.4) [ac]	6.1 (2.3) [b]	6.2 (2.4) [bc]	6.2 (2.3)	6.3 (2.3) [ac]	6.3 (2.3) [b]	6.3 (2.3) [bc]
Depression	6-24	10.2 (3.7)	10.8 (3.9) [ac]	10.8 (3.9) [b]	11.0 (3.9) [bc]	10.4 (3.9)	10.7 (3.8) [ac]	10.7 (3.8) [b]	10.7 (3.9) [bc]
Physical symptoms	11-44	19.6 (5.5)	21.3 (6.1) [ac]	21.1 (6.1) [bc]	21.7 (6.2) [bc]	18.3 (5.6)	19.1 (5.8) [ac]	18.9 (5.8) [b]	19.3 (5.8) [bc]
Social Support (total)	9-36	19.7 (4.9)	20.4 (5.0) [ac]	20.2 (5.1) [b]	20.9 (4.9) [bc]	20.4 (5.1)	20.2 (5.1) [ac]	19.9 (5.1) [bc]	20.4 (5.2)
Superiors' support	3-12	7.9 (2.2)	8.2 (2.3) [ac]	8.1 (2.3) [b]	8.3 (2.2) [bc]	7.7 (2.2)	7.6 (2.2) [ac]	7.5 (2.2) [bc]	7.6 (2.2)
Co-workers' support	3-12	6.8 (2.1)	6.9 (2.1) [ac]	6.8 (2.2)	7.1 (2.1) [bc]	7.2 (2.0)	7.0 (2.0) [ac]	6.9 (2.1) [bc]	7.0 (2.0) [bc]
Family support	3-12	5.0 (2.0)	5.4 (2.2) [ac]	5.3 (2.2) [b]	5.5 (2·2) [bc]	5.5 (2.2)	5.7 (2.2) [ac]	5.5 (2.2)	5.7 (2.2) [bc]

[a] $p<0.05$ vs. non-smokers (unpaired t test), [b] $p<0.05$ vs. non-smokers (Dunnett's test)

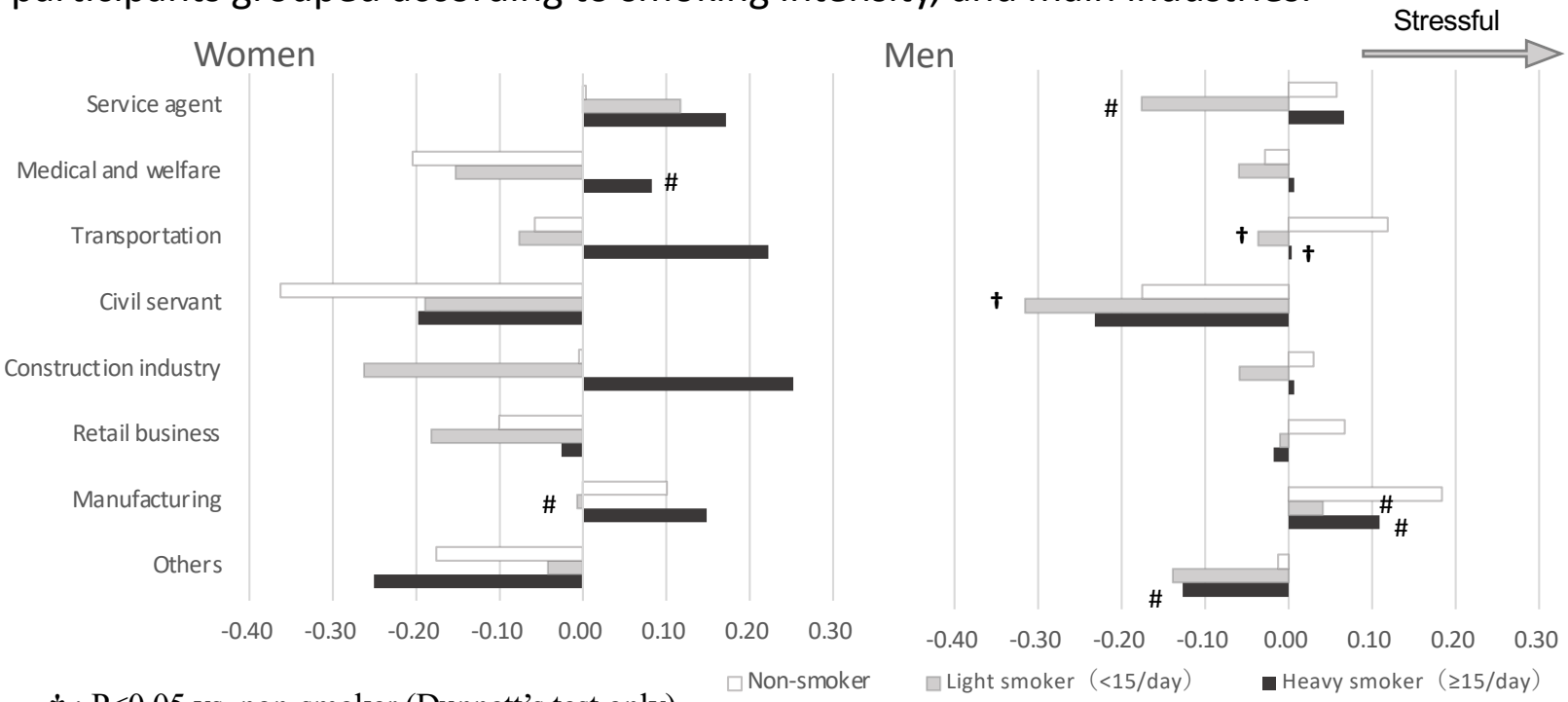
[c] $p<0.05$ vs. non-smokers (multivariate analysis adjusted for age, BMI, amount of alcohol consumption, frequency of alcohol drinking)

BJSQ: Brief Job Stress Questionnaire, BMI: body mass index

[Light smokers (LS)<15 cigarettes/day; Heavy smokers (HS) ≥15 cigarettes/day]

Supplemental Fugure1

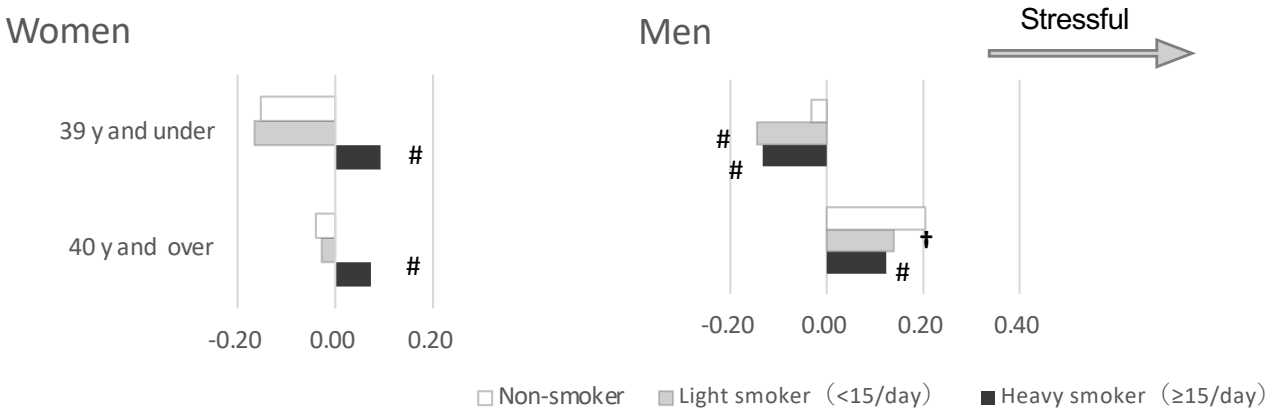
Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and main industries.



† : P<0.05 vs. non-smoker (Dunnett’s test only),
#: p<0.05 vs. non-smoker (Dunnett’s test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol drinking)

Supplemental Fugure2

Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and age group (≥40 y and ≤39 y)



†: $p<0.05$ vs. non-smoker (Dunnett’s test only),
#: $p<0.05$ vs. non-smoker (Dunnett’s test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and Frequency of alcohol drinking)
y: years old

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	*8-9*
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	8-9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	10-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	10-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Differences in Occupational Stress by Smoking Intensity and Gender in Cross-sectional Study of 59,355 Japanese Employees using the Brief Job Stress Questionnaire (BJSQ); The Niigata Wellness Study

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Secondary Subject Heading:	Mental health, Smoking and tobacco, Public health
Keywords:	MENTAL HEALTH, OCCUPATIONAL & INDUSTRIAL MEDICINE, PUBLIC HEALTH, PREVENTIVE MEDICINE

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Differences in Occupational Stress by Smoking Intensity and Gender in Cross-sectional Study of 59,355 Japanese Employees using the Brief Job Stress Questionnaire (BJSQ); The Niigata Wellness Study

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Word count: 3969

ABSTRACT

Objectives It has been hypothesized that smoking intensity may be related to occupational stress. This study aimed to investigate whether stress, including problems with superiors or co-workers, is a driver of smoking.

Design Cross-sectional Study

Setting and participants 59,355 employees (34,865 men and 24,490 women) across multiple occupations who completed a self-reported questionnaire-based occupational stress survey between Apr. 2016-Mar. 2017 in Niigata Prefecture.

Main outcome measures Stress scores for the Brief Job Stress Questionnaire (BJSQ) subscales summed up after assigning high points for high stress and converted to Z-scores based on the mean of all participants. Heavy smokers (HS) smoked ≥15 cigarettes/day and light smokers (LS) smoked <15 cigarettes/day and were compared to non-smokers (NS) by gender.

Results The main subscale items that were significantly associated with smoking status in both genders included "physical burden," "irritation," and "physical symptoms." In the analysis that included smoking intensity, the stress score for “co-workers’ support” was significantly lower for LS men than NS men (NS 0.091 ± 0.98, LS -0.027 ± 1.00, HS 0.033 ± 0.99), and was significantly higher for HS women than NS women (NS -0.091 ± 1.00, LS -0.080 ± 1.05, HS 0.079 ± 1.03). However, the stress score for “co-workers’ support” was low among women LS aged ≤39 years old in the manufacturing industry.

Conclusions It was speculated that LS men and some LS women gained "co-workers’ support" using smoking as a communication tool while reducing the degree of smoking. The existence of such "social smokers" suggested that to promote smoking cessation, measures are essential to improve communication between workers in addition to implementing smoking restrictions in the workplace.

Strengths and limitations of this study

- The strength of this study is that it is one of the largest comprehensive surveys of more than 50000 employed individuals in East Asia and describes a wide range of components of occupational stress, including support by superiors or co-workers.

- In addition to a simple comparison of smokers and non-smokers, we compared heavy smokers and light smokers separately to clarify stress factors characteristic of women who are heavy smokers and men who are light smokers, which has not been well studied.

- We have included industry-specific surveys to clarify conditions of support by co-workers according to smoking rates in workplaces.

- A limitation of this study is that it was a cross-sectional study and therefore causal relationships could not be identified.

INTRODUCTION

Smoking is not only a personal health problem that presents a significant risk for conditions such as malignancies and cardiovascular and respiratory diseases but also is a serious public health challenge, such as workplace secondhand smoke and work productivity issues.[1-4] Most studies that include smoking and occupational stress consider both as risk factors for non-communicable diseases and unfavorable habits such as those related to alcohol drinking, overeating, and exercise. Only a few studies have focused directly on the relationship between smoking and occupational stress.[5-9] Since the serious health hazards of smoking have become recognized, the smoking rate among Japanese men has decreased year by year, although it is still high worldwide and the smoking rate among women remains flat.[10, 11] Under these circumstances, the revised Health Promotion Law was fully enforced in Japan in 2020. This law stipulates that "premises of public facilities such as hospitals and schools are non-smoking, commercial and industrial facilities such as offices and restaurants are non-smoking in principle, and in case of violations, a penalty of 500,000 yen or less" will be enforced. However, in existing small-scale restaurants or bars, smoking bans are not enforced, and exceptions are allowed as a transitional measure, which makes this a slightly loose regulation.[12]

Research on the backgrounds of smokers in Japan has been reported in recent years, mainly on educational disparities [13, 14] and industry differences. [15] Although there are few academic studies published in English addressing why Japanese workers continue to smoke or why they are unable to quit, in general, many smokers cite "stress" as a reason. [16, 17] Although it was not a study of reasons for smoking, a recent Japanese survey of the general public that included those who were not working reported an association between smoking intensity and ‘serious psychological distress’ in women. [18] In addition, a market research company (Cross Marketing Inc. Tokyo.

Japan) [19] conducted a survey on reasons for smoking and found that "stress" was cited by 40.4% of smokers as the main reason for smoking in Japan.

There are multiple aspects to occupational stress, and various stress models have been developed to elucidate causal associations with occupational stress. Among them, workload (job demand) and work discretion (job control) are widely accepted as representative causes.[20] [21] In addition, workplace relationships are important as a buffer against stress. The demand-control-support (DCS) model, which adds support from co-workers and supervisors to demand and control, is mainly used to investigate the association between cardiovascular disease and work stress in research. [22, 23] In recent years, not only the DCS model but also indicators such as workplace social capital or organizational justice have been used to investigate workplace support, but the relationship between smoking and these stress indicators is still controversial.

For example, Kouvonen and colleagues reported that lower “job control” was associated with increased smoking intensity among women civil servant in Finland while no such association was found in men.[7] In a study of Japanese men in a single workplace, Kawakami and colleagues suggested that the intensity of smoking increased in Japanese men in a group with low job control and low social support.[8] Fukuoka et al. tracked the outcome of smoking cessation for two years and reported no association between stressors and continued smoking cessation in a similar group of Japanese male workers. [24] Studies using other indicators also found that "low confidence in workplace organizations" was associated with smoking,[9] and "poor trust relationship with superiors" was associated with smoking in women managers.[5] On the other hand, the opposite result was reported where "good workplace support" was associated with smoking among women in the nursing profession.[25] Although has been reported that "social connections" are involved in both smoking and smoking cessation,[26] other conditions, such as related to workplace environment or duties, might be required for social support to help control smoking.

Because of the very limited number of large-scale comprehensive studies on a variety of industries in the East Asian region, where smoking rates are known to be high, no consistent conclusions can be drawn on the association between various occupational stresses, such as lack of workplace support, and smoking. Therefore, we administered a detailed occupational stress survey, including smoking intensity and workplace support, to approximately 60,000 employees from industries of different sizes and categories to determine the relationship between smoking intensity and occupational stress and differences in the relationship by gender, age, and industry.

We hypothesized that smokers experience more occupational stressors than non-smokers, and that the greater the stress, the higher the intensity of smoking. We also hypothesized that better workplace support would buffer stress and suppress smoking. To test these hypotheses, we compared the stress scale of non-smokers, light smokers, and heavy smokers by gender. Since supportive environments in the workplace vary according to the age of workers and industry, we added comparisons by age group and industry group. Therefore, through our results we could identify measures to promote smoking cessation by reducing working smokers' stress and improving the work environment.

METHODS

Survey participants

Among 64,279 employees who underwent an occupational health examination and stress check based on the Occupational Safety and Health Act between Apr. 2016-Mar. 2017 in Niigata Prefecture, 34,865 men (mean age 41.8 years old) and 24,490 women (mean age 41.9 years old) participated in this study. Excluded were employees whose gender was unknown, had incomplete examination data, an incomplete stress check response, or were ≤19 years old or ≥70 years old. The industry type was classified

according to a large number of persons working at seven occupations and a smaller number of workers in an eighth category designated as "other".

Also, in this survey participants were limited to workers at establishments in and around Niigata Prefecture; thus, participants were not representative of workers nationwide.

Patient and Public Involvement

Patients were not involved in this study.

Stress check

The 57-item “Brief Job Stress Questionnaire” (BJSQ) developed and validated by Shimomitsu and colleagues was used to assess occupational stress.[27] It has been used in previous studies as well as in workplaces across the country by the Ministry of Health, Labour and Welfare in guiding the Stress Check Program.[28] The purpose of this program was to assess stress in individual workers and in the work environment, and its results were reported to be associated with long-term leave and turnover of workers. [29, 30] Participants were required to answer questions on the BJSQ using a Likert scale of one to four points. The BJSQ contains several related questions, and the scores of the individual questions are added together to produce a result for each category. The total score for each category resulted in high points for high stress (simple total score). Question content was broadly divided into three components: "Job Stressors," "Mental and Psychological Stress Reactions (“Stress Reaction”) ", and "Social Support." "Job Stressors" has nine subscales (job demands, job control, meaningfulness of work, work environment, suitability for work, physical burden, skill utilization, required job quality, interpersonal relationships), and “Stress Reaction” has six subscales (vigor, irritation, fatigue, anxiety, depression, physical symptoms). Originally, "Social Support" included four subscales (superiors, co-workers, family and/or friends (family), life satisfaction), but “life satisfaction” was excluded because it

was not related to support resources. Its elimination left three subscales. Scores were tabulated for each of these three components and 18 subscales.

These simple total scores were compared and examined using Z-score values (Z-scores) standardized from the average score of participants for each component or each subscale. Results with reference to the simple total scores are presented in Supplemental Table 1.

Smoking status and intensity

Information on smoking status (smokers or non-smokers) and the number of cigarettes smoked per day was obtained from the medical checkup questionnaire. Based on the median number of cigarettes smoked in the all smokers (AS) group, we defined those who smoked <15 cigarettes/day as light smokers (LS) and those who smoked ≥15 as heavy smokers (HS). In the LS, HS, and non-smoker (NS) groups, the distribution of chronological age was calculated in ten-year increments and the stress check scores (Z-scores) were compared among the three groups.

Analysis of "Co-workers' support" by industry type and workers' age

To investigate differences by industry and age, we divided the participants into two age groups (≥40 years old or ≤39 years old) and compared the "co-workers' support" subscale by industry categories.

Statistical analysis

Smoking was compared between the AS and NS groups using unpaired t-tests for all 18 subscales, and additionally compared using nominal logistic analysis adjusted for age, body mass index (BMI), amount of alcohol consumption, and drinking frequency.

Based on the results obtained from the basic statistics, the average age and BMI differed significantly according to smoking intensity. Therefore, age and BMI were selected as

items for adjustment. In addition, since a prior publication [31] showed that many workers smoke when drinking, drinking behavior was also an adjustment item. To clarify the synergy of stress indicators that are strongly related to smoking status, logistic regression analysis was conducted for smoking status to 18 subscales. Three models were tried: model-0 (without adjustment), model-1 (adjusted for age and BMI), and model-2 (Model-1 with additional adjustment for amount and frequency of alcohol consumption), and the three subscales with the highest odds ratios were selected in every trial. Participants with positive or zero Z-scores on the selected subscales were classified as stressed (+) and those with negative Z-scores were classified as stressed (-) to form two groups. Nominal logistic regression analysis was performed on eight combinations of three subscale stresses (+) or (-).

Regarding smoking intensity, the Z-scores of the three components of the BSJQ and the 18 subscales were compared for the NS, LS, and HS groups by the Dunnett test with NS as the control. Z-scores were examined by multivariate analysis adjusted for age and BMI, amount of alcohol consumption, and drinking frequency. Additionally, an examination of "co-workers' support" by industry and age group compared the NS, LS, and HS groups by multivariate analyses adjusted for BMI, amount of alcohol consumption, and drinking frequency.

JMP for Macintosh (14.0.0) was used for statistics.

Ethical Considerations

The study was approved by the Ethics Committee of Niigata University [2017-0401], and we have obtained consent for the use of personal information from all participants on the health checkup. After confirming the concordance of the data, personal information such as the participant's name, personal identification code for health checkup orders, and the name of the company or office to which the worker belonged was removed before using the data for analysis.

This study does not involve animal subjects.

RESULTS

The smoking rate for the entire study population was 13.6% for women and 41.4% for men. For both genders, the smoking rate by age group was highest in the 40s and the lowest in the 20s. There were more LS and fewer HS among women in all age groups. In men, the number of LS was greatest among those in their 20s. The industry category with the lowest smoking rate was civil servants of both genders (Table 1).

Mean age of women smokers was significantly older than for NS; in addition, both LS and HS women were significantly older than NS women. Among men, LS were significantly younger than NS, and HS were significantly older than NS. In women, BMI was significantly lower in LS and higher in HS than in NS, but no significant difference was observed between NS and AS. In men, BMI was significantly lower in AS and LS than in NS, but there was no significant difference in BMI between HS and NS (Table 1).

As shown in Table 2, many of the stress subscales were independently and significantly associated with smoking. The odds ratios for each subscale were almost the same in the three models, and even after taking into account the amount and frequency of alcohol consumption, the three highest odds ratios for both genders were for "physical burden," "irritation," and "physical symptoms." Conversely, “co-workers’ support” had the lowest odds ratio of all subscales, especially for men. The risk increased with the combination of the three factors of “physical burden,” “irritation,” and “physical symptoms” for both genders (Table 3).

Compared with NS, the BJSQ simple total score for women AS had significantly higher stress values than for NS in all components (Supplemental Table 1). When compared to NS by smoking intensity (Fig. 1), Z-scores for almost all subscales for women HS were significantly higher, with only "job demands," "suitability for work," and "required job

quality" being not significantly different between NS and HS. Results of the multivariate analysis for all “Social Support” subscales also showed that HS women had significantly higher Z-score values than NS women.

In men, the AS group had slightly but significantly lower scores for “Social Support” than the NS group (Supplemental Table 1). According to smoking intensity, the “Social Support” score compared with NS was significantly lower in LS by multivariate analysis, but no statistical difference was observed between NS and HS (Fig. 1). Significantly higher stress scores were shown for "job demands" and "required job quality" in LS than in NS.

Since “co-workers’ support” differed from the other subscales in that smokers were less stressed than NS, we added an analysis that included industry type and chronological age (≤39 years old vs. ≥40 years old) (Fig. 2). By industry, in women, HS in the medical and welfare industry had the highest stress scores for “co-workers’ support” compared to NS in the same industry. Exceptionally, LS in the manufacturing industry were characterized by lower stress scores for “co-workers’ support” than NS. In men, LS in the service industry, LS and HS in the manufacturing industry, and HS in ‘other’ industries had significantly lower stress scores for “co-workers’ support” than NS in their respective industries. (Supplemental Figure 1) By age group, in women both HS ≥40 years old and HS ≤39 years old had the highest stress scores for “co-workers’ support” compared to NS in their respective age group. In men, HS ≥40 years old, HS ≤39 years old and LS ≤39 years old were characterized by lower stress scores for “co-workers’ support” than NS in their respective age group. (Supplemental Figure 2) By age group and industry, in women ≤39 years old, HS in the medical and welfare industry had the highest stress scores for “co-workers’ support” compared to NS in the same industry. LS in the manufacturing industry had lower stress scores for “co-workers’ support” than NS in the same industry. In men of ≤39 years old, LS in the service industry and LS in the manufacturing industry had significantly lower stress

scores for “co-workers’ support” than NS in their respective industries. Also, in men ≥40 years old, HS in the manufacturing industry had significantly lower stress scores for “co-workers’ support” than NS in that industry. (Figure 2)

DISCUSSION

This is the first large-scale study to investigate a wide range of components of occupational stress and smoking intensity using the BSJQ. We have clarified occupational stress specific to smokers on the following three points. (1) Subscales independently associated with smoking in both genders were "physical burden", "irritation" and "physical symptoms". However, since there was no synergistic effect of these three major stress subscales, so we felt it was not important to prioritize addressing these stressor or stress response in the workplace. (2) Women HS were generally highly stressed. (3) Men LS obtained more "co-workers’ support" even though they had higher stressors such as "job demands." As hypothesized, the larger the amount of smoking in women, the greater the stress in all three components of “Job Stressors”, “Stress Reactions”, and “Social Support”. But in men, smoking intensity and social support did not support the hypothesis. The reason why smoking status was strongly associated with "physical burden" rather than "job demands" is that "small breaks to rest the body" may be strongly linked to smoking and become a habit in the manufacturing, transport, and construction industries in men. The high rate of smoking in these occupations was already been shown in a survey of medium- and small-sized companies in Japan.[15] "Job demands" primarily identifies the degree of psychological burden whereas "physical burden" was evaluated by only one question asking whether the work involved physical labor. In an earlier occupation-specific survey, Strickland and colleagues reported nearly twice the rate of smoking among white construction workers compared with whites in general in Missouri, USA.[32] Chau and colleagues examined work content in assessing "physical job demands" and reported that workers

with a higher total amount of physical work, such as "working under bad weather" and "using vibration tools," smoked greater numbers of cigarettes in the Lorene region of France.[33] This is probably because such workers often work on the same team and recognize smoking as a “means of dealing with work difficulties.” Furthermore, smokers recognize that smoking can relieve the "irritation" that they feel as occupational stress, but this "irritation" can also occur as symptoms of nicotine withdrawal due to a temporary interruption of smoking during work.[34] In addition, nicotine withdrawal can be manifested by dizziness and palpitations**.** Parrott in a review stated that smokers tended to report high “daily” stress and that stress symptoms such as irritation increase when they cannot smoke frequently, and that successful quitters experience reduced “stress.”[35] Strictly speaking, these complaints by smokers may not be "physical symptoms" of occupational stress.

The reasons why women HS were highly stressed are complex. Women HS generally have high scores for "Job Stressors" such as "job control," "work environment," and "interpersonal relationships," and they may be engaged in low discretionary tasks in the first place. In addition, it was shown that women smokers not only workers in general were more likely than men to express negative emotions, such as anxiety, regarding the stress response;[36] biological and socio-environmental ‘sex differences’ are being explored.[37] Tomioka et al. [18] suggested the necessity of coping with psychological distress as a smoking cessation measure for Japanese women, including the non-regularly employed and unemployed. Our results suggest that coping with stress symptoms may also be useful for smoking cessation among regularly employed women who are more financially stable. Similarly, the results of "Social Support" suggested that women HS engaged in tasks with less support than NS. Conversely, the stress caused by lack of social support may have led women to smoke. Creswell and colleagues reported that in general "social support" aided in the success of smoking cessation.[38]

In men, there might be a kind of “social smoking” because smokers reported better “Social Support” than non-smokers. Earlier reports captured the phenomenon that college student smokers smoked only when with friends and acquaintances,[39, 40] and the presence of youth who habitually smoked only on social occasions, such as at parties, became recognized. They were reported to display positive actions in preventing secondhand smoking by non-smokers.[41] Even in Japan, smokers who "do not smoke at home" exist, and their restrained smoking style was reported.[42] This type of smoking, which is highly related to peers, has been defined as "peer smoking".[33, 43] The results for "co-worker’s support" suggest that LS are more likely to be social smokers, especially in the service and manufacturing industries. Not only men, but also women LS in the manufacturing industry had significantly better co-workers' support than NS. This means that LS in these industries may feel closer to their co-workers when they smoke.

Research on social support and smoking in the workplace suggested that smoking functioned as a communication tool. In China, where the smoking rate is as high as 38%, it is highly speculated that supervisors and co-workers are smokers, so smokers are more likely to obtain support by supervisors.[44] A study in North America reported (smoking rate: 26%), that supervisors’ support inhibited smoking, but co-workers’ support did not.[45] In addition, a study of Brazilian civil servant men (smoking rate: 17%) reported that social support suppressed smoking.[46] Thus, the association between “social support” and smoking may be explained by differences in the workplace smoking rate, with better relationships between non-smokers in environments with a low smoking rate and better communication between smokers in workplaces with high smoking rates. Men LS probably have sufficient knowledge about the health hazards of smoking to suppress their smoking intensity. However, they may be psychologically unable or fail to initiate smoking cessation because they may be afraid of losing social support in a workplace with a high smoking rate. Indeed,

interventional surveys of smoking cessation guidance have reported that workplaces with a higher percentage of smokers have a stronger impact on peer smoking behavior and lower rates of long-term smoking cessation.[43]

Smoking rates may also be a factor in "co-workers' support" scores. Among women, "co-workers' support" was better for LS than NS in the manufacturing industry. The smoking rate among women in the manufacturing industry was relatively high at 15.8%, and it is estimated that women obtain "co-workers' support" through smoking in such workplaces. These findings seemed to mean that good communication through smoking in a workplace could occur if the smoking rate was relatively high. In addition, the relationship between co-worker support and smoking intensity within industries may differ depending on work duties. In health and social work, smoking is perceived as undesirable, and HS who take frequent smoking breaks are imagined to have reduced communication with colleagues. Promoting smoking cessation among youth is desirable for their health, and smoking regulations may be acceptable especially for young social smokers due to their behavioral characteristics. Common social smoking measures in workplaces include bans on smoking on workplace premises and during working hours.[47] Simultaneously, it is necessary to promote communication among workers in the workplace, even under a non-smoking environment. Alternatives to smoking that promote informal communication include taking short breaks, increasing opportunities for face-to-face conversations, and increasing opportunities for interaction with workers in other departments based on the benefits that smokers have received. [48]

Significance and limitations of this study

The strength of this study is that it was a large comprehensive occupational stress survey of employed individuals in East Asia. Therefore, this study could investigate the association between a wide range of occupational stresses and smoking intensity across multiple occupations, suggesting for the first time that workplace stressors and

supportive conditions may differ according to smoking rates in workplaces and by gender.

A limitation of this study is that it was cross-sectional and therefore causal relationships could not be identified. Factors such as working hours, job position, and company size, which could not be surveyed at this time, may have contributed to the association between smoking and physical burden. Also, because the number of cigarettes smoked was provided by self-report in a health checkup questionnaire, responses may be inaccurate, such as inputting less than the actual dose. Reports by users of electronic cigarettes and heated tobacco products users may not have been accurate because it is difficult to translate these products into the number of cigarettes smoked or because users are not aware of them as tobacco products.

CONCLUSIONS

The occupational stress of smokers of both genders may be related to the subjective "physical burden," "irritation," and "physical symptoms." In analyses of smoking intensity and gender, both strong psychosomatic stress symptoms such as "irritation" and "physical symptoms" and lack of social support at work were observed in women HS; however, in contrast, over all smokers' “co-workers’ support” was good in men. In addition, in young women LS in the manufacturing industries, where the smoking rate is relatively high, we observed significantly better “co-workers’ support” compared to that in NS, suggesting the presence of "social smokers" who continue to smoke small amounts as a communication tool in these workplaces.

These results suggest that improvement of the communication environment among workers may be essential for the promotion of smoking cessation at the same time as smoking bans in worksites and public facilities.

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Contributorship statement

ST, KK, and HS planned and designed the study. MT, KM, MO, and KS did project administration, funding acquisition and data collection. ST and KK calculated data for the statistical analyses, did the literature review and wrote the first draft of the manuscript following discussion with all authors, MK, SK, KF, and HS contributed to the editing of the manuscript. All authors participated in data interpretation, commented on subsequent drafts, approved the final manuscript, and agreed to submit the manuscript for publication.

Declaration of interests

The authors declare no conflict of interest.

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Data sharing statements

No additional data available.

Table 1. Demographics of Study Participants (n=59,355)

Participants	Women					Men				
Smoking status		Non-smokers	Smokers				Non-smokers	Smokers		
			All smokers					All smokers		
smoking intensity				Light smokers	Heavy smokers				Light smokers	Heavy smokers
Average (SD)										
Age [y]	41.9 (12.2)	41.7 (12.4)	43.3 (10.6) [a]	43.0 (10.9) [b]	44.2 (9.8) [b]	41.8 (12.5)	41.4 (13.0)	42.3 (11.8) [a]	38.5 (12.0) [b]	44.4 (11.2) [b]
BMI [kg/m^2]	21.76 (3.90)	21.77 (3.88)	21.71 (3.98)	21.55 (3.84) [b]	22.08 (4.25) [b]	23.20 (3.73)	23.29 (3.76)	23.08 (3.68) [a]	22.70 (3.60) [b]	23.29 (3.71)
Total Participants										
n <smoking rate %>	24,490	21,148	3,342 <13.6>	2327 < 9.5>	1015 < 4.1>	34,865	20,438	14,427 <41.4>	5219 <15.0>	9208 <26.4>
Age group [y]										
20-29	4,936	4,544	392 < 7.9>	313 < 6.3>	79 <1.6>	7,068	4,698	2,370 <33.5>	1404 <19.9>	966 <13.7>
30-39	5,771	4,958	813 <14.1>	575 <10.0>	238 <4.1>	9,050	5,100	3,950 <43.7>	1658 <18.3>	2292 <25.3>
40-49	6,293	5,150	1,143 <18.2>	743 <11.8>	400 <6.4>	8,404	4,561	3,843 <45.7>	1085 <12.9>	2758 <32.8>
50-59	5,537	4,746	791 <14.3>	558 <10.1>	233 <4.2>	6,756	3,762	2,994 <44.3>	733 <10.8>	2261 <33.5>
60-69	1,953	1,750	203 <10.4>	138 < 7.1>	65 <3.3>	3,587	2,317	1,270 <35.4>	339 < 9.5>	931 <25.9>
Industry category										
Service agent	1,368	1,157	211 <15.4>	145 <10.6>	66 <4.8>	2,329	1,296	1,033 <44.4>	346 <14.9>	687 <29.5>
Medical and welfare	5,121	4,424	697 <13.6>	511 <10.0>	186 <3.6>	1,907	1,205	702 <36.8>	365 <19.1>	337 <17.7>
Transportation	774	641	133 <17.2>	85 <11.0>	48 <6.2>	4,354	2,240	2,114 <48.6>	416 < 9.6>	1698 <39.0>
Civil servant	3,355	3,178	177 < 5.3>	137 < 4.1>	40 <1.2>	2,299	1,651	648 <28.2>	277 <12.0>	371 <16.1>
Construction industry	366	314	52 <14.2>	34 < 9.3>	18 <4.9>	2,072	1,010	1,062 <51.3>	227 <11.0>	835 <40.3>
Retail business	3,639	3,040	599 <16.5>	405 <11.1>	194 <5.3>	3,632	2,212	1,420 <39.1>	566 <15.6>	854 <23.5>
Manufacturing	8,396	7,070	1,326 <15.8>	906 <10.8>	420 <5.0>	15,689	9,183	6,506 <41.5>	2674 <17.0>	3832 <24.4>
Other	1,471	1,324	147 <10.0>	104 < 7.0>	43 <2.9>	2,583	1,641	942 <36.5>	348 <13.5>	594 <23.0>
Alcohol consumption										
Amount [drinks/day]										
-2.2	18,470	16,481	1,989	1,419	570	17,064	10,947	6,117	2,333	3,784
2.3-4.4	4,511	3,614	897	639	258	11,398	6,233	5,165	1,889	3,276
4.5-6.6	1,212	867	345	209	136	4,807	2,447	2,360	733	1,627
6.7-	297	186	111	60	51	1,596	811	785	264	521
Frequency										
rarely	12,528	11,220	1,308	906	402	10,717	6,996	3,721	1,331	2,390
occasionally	8,533	7,501	1,032	760	272	12,042	7,446	4,596	2,062	2,534
everyday	3,429	2,427	1,002	661	341	12,106	5,996	6,110	1,826	4,284

[a] $p<0.05$ vs. non-smokers (unpaired t test), [b] $p<0.05$ vs. non-smokers (Dunnett's test)

[Light smokers <15 cigarettes/day; Heavy smokers ≥15 cigarettes/day; SD: standard deviation; BMI: body mass index; y: years old]

SD is shown in parentheses () in the age and BMI columns, and smoking rate % is shown in the column < > for the Total Participants, Age group, Industry category, and Alcohol consumption.

Table 2. Odds ratios of smokers to non-smokers for a one standard deviation increase in the BJSQ stress Z-score of men and women. (by subscales)

	Women OR [95%CI]			Men OR [95%CI]		
BJSQ Subscales	Model-0	Model-1	Model-2	Model-0	Model-1	Model-2
Job Stressors						
Job demand	0.95 [0.90-1.00]	0.96 [0.91-1.00]	0.95 [0.90-1.00]	0.93 [0.91-0.96]	0.95 [0.92-0.98]	0.95 [0.92-0.97]
Job control	1.00 [0.96-1.04]	0.99 [0.95-1.03]	0.99 [0.95-1.04]	0.95 [0.93-0.98]	0.95 [0.93-0.97]	0.95 [0.93-0.98]
Meaningfulness of work	1.03 [0.98-1.08]	1.01 [0.96-1.06]	1.02 [0.97-1.08]	1.04 [1.00-1.07]	1.02 [0.99-1.05]	1.02 [0.99-1.05]
Work environment	0.98 [0.94-1.02]	0.97 [0.93-1.01]	0.96 [0.92-1.01]	0.99 [0.97-1.01]	0.99 [0.96-1.01]	0.98 [0.96-1.01]
Suitability for work	0.90 [0.86-0.95]	0.92 [0.87-0.96]	0.90 [0.86-0.95]	1.00 [0.97-1.03]	1.01 [0.98-1.04]	1.01 [0.98-1.04]
Physical burden	1.17 [1.12-1.21]	1.15 [1.11-1.20]	1.17 [1.12-1.22]	1.14 [1.11-1.17]	1.15 [1.12-1.18]	1.15 [1.13-1.18]
Skill utilization	1.04 [1.00-1.08]	1.05 [1.01-1.09]	1.06 [1.02-1.11]	0.97 [0.95-1.00]	0.97 [0.95-1.00]	0.98 [0.96-1.01]
Required job quality	0.95 [0.90-1.00]	0.94 [0.90-0.99]	0.94 [0.90-0.99]	1.02 [0.99-1.05]	1.02 [0.99-1.05]	1.02 [0.99-1.05]
Interpersonal relationship	1.10 [1.05-1.15]	1.10 [1.05-1.15]	1.09 [1.04-1.14]	1.07 [1.04-1.10]	1.08 [1.05-1.11]	1.07 [1.04-1.10]
Stress Reaction						
Vigor	1.01 [0.97-1.06]	1.01 [0.97-1.06]	1.02 [0.97-1.07]	1.03 [1.01-1.06]	1.03 [1.00-1.06]	1.03 [1.00-1.06]
Irritation	1.20 [1.14-1.25]	1.22 [1.16-1.28]	1.16 [1.11-1.22]	1.15 [1.12-1.18]	1.16 [1.13-1.20]	1.15 [1.11-1.18]
Fatigue	1.06 [1.01-1.12]	1.08 [1.02-1.14]	1.09 [1.03-1.16]	1.09 [1.05-1.12]	1.11 [1.07-1.15]	1.12 [1.08-1.16]
Anxiety	0.89 [0.84-0.95]	0.89 [0.84-0.94]	0.90 [0.85-0.95]	0.92 [0.89-0.96]	0.92 [0.88-0.95]	0.92 [0.89-0.95]
Depression	0.94 [0.89-1.00]	0.97 [0.91-1.04]	0.97 [0.91-1.04]	0.90 [0.87-0.94]	0.92 [0.89-0.96]	0.92 [0.88-0.95]
Physical symptoms	1.27 [1.21-1.33]	1.26 [1.20-1.33]	1.25 [1.19-1.32]	1.15 [1.12-1.19]	1.14 [1.10-1.17]	1.13 [1.10-1.17]
Social Support						
Superiors' support	1.02 [0.98-1.07]	1.01 [0.96-1.06]	1.01 [0.96-1.06]	0.94 [0.91-0.97]	0.93 [0.90-0.96]	0.93 [0.90-0.96]
Co-workers' support	0.91 [0.87-0.96]	0.91 [0.87-0.95]	0.92 [0.88-0.97]	0.86 [0.83-0.88]	0.84 [0.82-0.87]	0.85 [0.82-0.88]
Family support	1.15 [1.10-1.19]	1.13 [1.09-1.18]	1.13 [1.09-1.18]	1.11 [1.08-1.14]	1.11 [1.09-1.14]	1.12 [1.10-1.15]

BJSQ: Brief Job Stress Questionnaire, OR: Odds ratios

Model-0: Logistic analysis not adjusted,

Model-1: Logistic analysis adjusted by age and body mass index (BMI), and

Model-2: Logistic analysis adjusted by age, BMI, amount of alcohol consumption, and frequency of alcohol consumption)

Table 3. Odds ratios of smoking to not smoking for the BSJQ subscale combinations highly associated with smoking.

			OR (95%CL)	OR (95%CL)
Physical symptoms	Irritation	Physical burden	Women	Men
(-)	(-)	(-)	1.00	1.00
(-)	(-)	(+)	1.36 [1.18-1.56]	1.27 [1.19-1.36]
(+)	(-)	(-)	1.47 [1.25-1.73]	1.16 [1.05-1.28]
(-)	(+)	(-)	1.53 [1.28-1.82]	1.35 [1.24-1.47]
(-)	(+)	(+)	1.73 [1.47-2.03]	1.52 [1.41-1.65]
(+)	(-)	(+)	1.93 [1.66-2.23]	1.66 [1.52-1.81]
(+)	(+)	(-)	2.06 [1.79-2.38]	1.45 [1.33-1.58]
(+)	(+)	(+)	2.63 [2.31-3.00]	1.79 [1.67-1.93]

(+): positive z-score, (-): negative z-score

Figure 1.

Z-scores of components and subscales on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity.

† P<0.05 vs. non-smokers (Dunnett's test only), #: p<0.05 vs. non-smokers (Dunnett's test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

Figure 2.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, age group (≥40 y and ≤39 y) and main industries.

†: p<0.05 vs. non-smokers (Dunnett's test only), #: p<0.05 vs. non-smokers (Dunnett's test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

y: years old

Supplemental Figure 1.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity and main industries.

†: $p<0.05$ vs. non-smokers (Dunnett's test only), #: $p<0.05$ vs. non-smokers (Dunnett's test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

Supplemental Figure 2.

Z-scores of "co-workers' support" subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, age group (≥40 y and ≤39 y)

†: $p<0.05$ vs. non-smokers (Dunnett's test only),

#: $p<0.05$ vs. non-smokers (Dunnett's test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

y: years old

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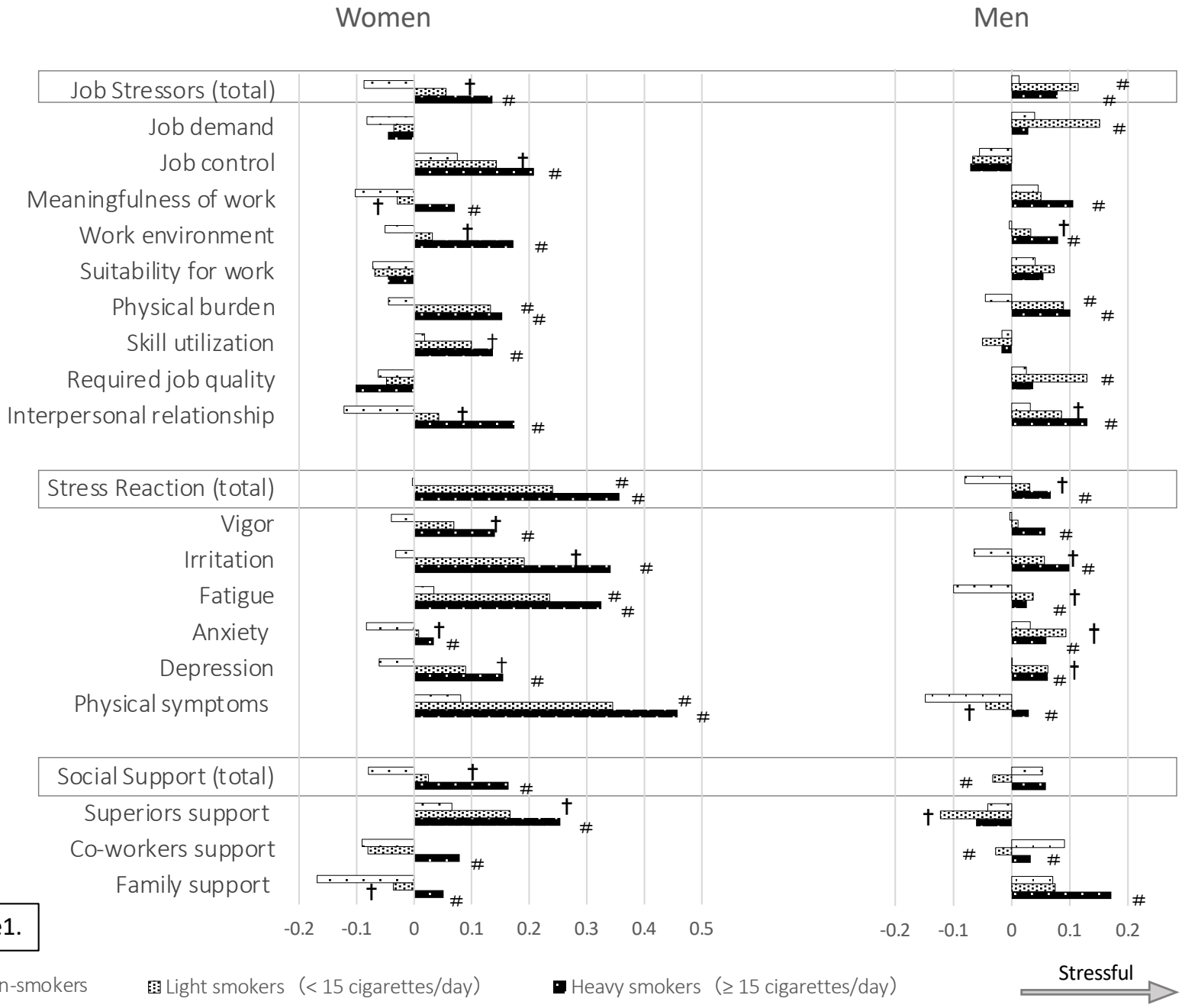

Women
Men
Job Stressors (total)
Job demand
Job control
Meaningfulness of work
Work environment
Suitability for work
Physical burden
Skill utilization
Required job quality
Interpersonal relationship
Stress Reaction (total)
Vigor
Irritation
Fatigue
Anxiety
Depression
Physical symptoms
Social Support (total)
Superiors support
Co-workers support
Family support
-0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
-0.2 -0.1 0 0.1 0.2
Non-smokers
Light smokers (< 15 cigarettes/day)
Heavy smokers (≥ 15 cigarettes/day)
Stressful

Figure1.

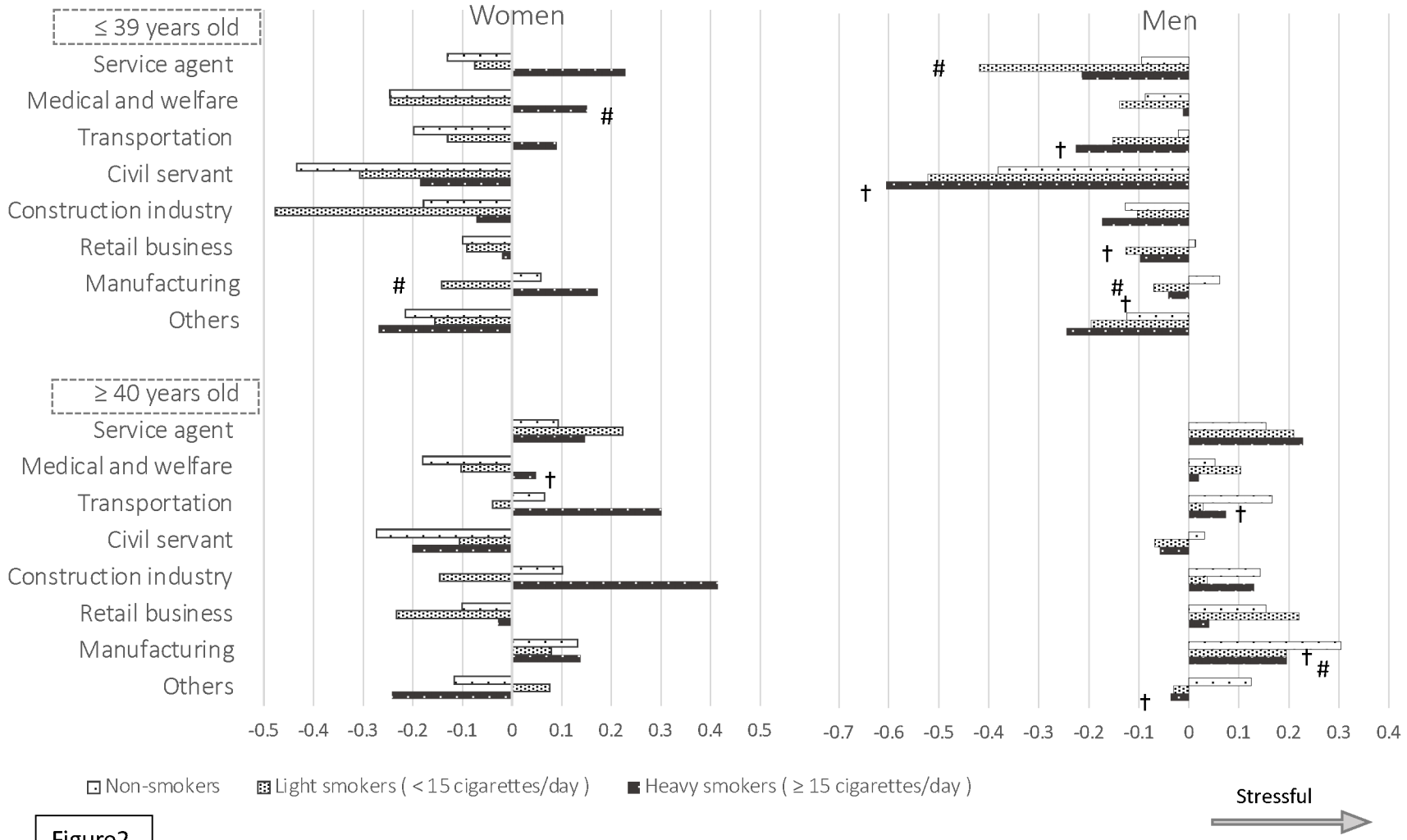
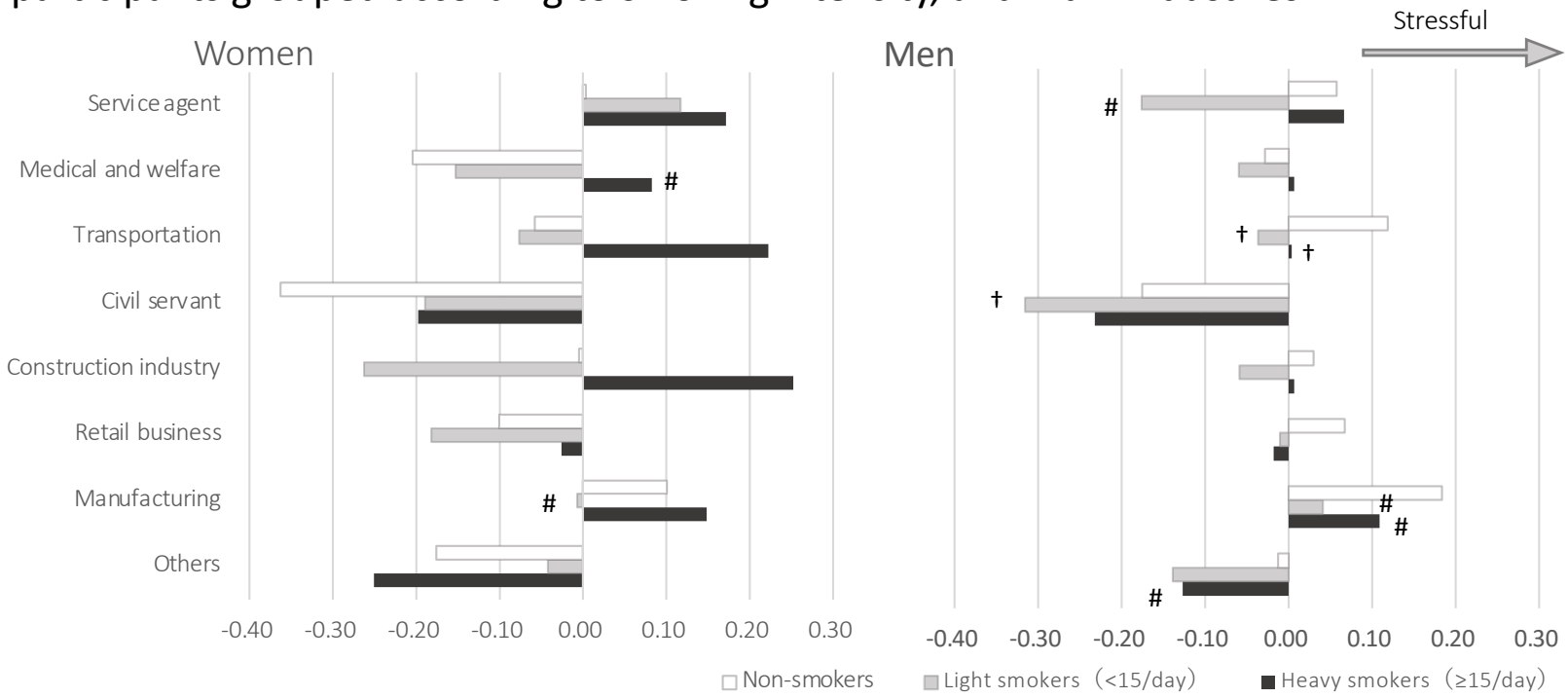

Women
Men
≤ 39 years old
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
≥ 40 years old
Service agent
Medical and welfare
Transportation
Civil servant
Construction industry
Retail business
Manufacturing
Others
-0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4 0.5
-0.7 -0.6 -0.5 -0.4 -0.3 -0.2 -0.1 0 0.1 0.2 0.3 0.4
Non-smokers
Light smokers (< 15 cigarettes/day)
Heavy smokers (≥ 15 cigarettes/day)
Stressful

Figure2.

Supplemental Fugure1

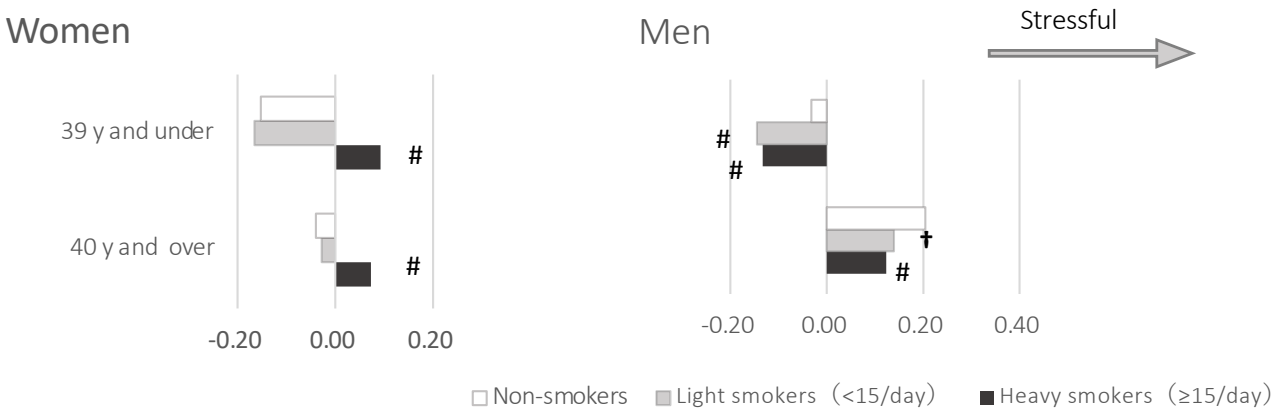
Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and main industries.



† : P<0.05 vs. non-smokers (Dunnett’s test only),
#: p<0.05 vs. non-smokers (Dunnett’s test and multivariate analysis adjusted for age, body mass index, amount of alcohol consumption, and frequency of alcohol consumption)

Supplemental Fugure2

Z-scores of “co-workers’ support” subscale on the Brief Job Stress Questionnaire (BSJQ) by participants grouped according to smoking intensity, and age group (≥40 y and ≤39 y)



† : p<0.05 vs. non-smokers (Dunnett’s test only),
#: p<0.05 vs. non-smokers (Dunnett’s test and multivariate analysis adjusted for body mass index, amount of alcohol consumption, and frequency of alcohol consumption)
y: years old

Supplemental Table 1. BJSQ simple total score by smoking intensity group: 3 components and 18 subscales

BJSQ Stress components & subscales	Range of points	Women				Men			
		Non-smokers (NS) <control>	smokers			Non-smokers (NS) <control>	Smokers		
			All smokers (AS)	Light smokers (LS)	Heavy smokers (HS)		All smokers (AS)	Light smokers (LS)	Heavy smokers (HS)
		average (SD)				average (SD)			
Job Stressors (total)	17-68	41.3 (6.8)	42.4 (6.9) [ac]	42.3 (6.8) [b]	42.8 (7.1) [bc]	42.0 (6.8)	42.5 (6.7) [ac]	42.7 (6.6) [bc]	42.4 (6.7) [bc]
Job demands	3-12	8.0 (2.1)	8.1 (2.1) [ac]	8.1 (2.0)	8.1 (2.1)	8.3 (2.1)	8.4 (2.0) [ac]	8.5 (2.0) [bc]	8.3 (2.1)
Job control	3-12	7.8 (2.0)	8.0 (2.1) [ac]	8.0 (2.1) [b]	8.1 (2.1) [bc]	7.6 (2.0)	7.5 (2.0)	7.5 (2.0)	7.5 (2.0)
Meaningfulness of work	1-4	2.1 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.9) [bc]	2.2 (0.8)	2.3 (0.8) [ac]	2.2 (0.8)	2.3 (0.8) [bc]
Work environment	1-4	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.5 (1.0) [bc]	2.3 (1.0)	2.4 (1.0) [ac]	2.3 (1.0) [b]	2.4 (1.0) [bc]
Suitability for work	1-4	2.1 (0.7)	2.1 (0.8)	2.1 (0.7)	2.1 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)	2.2 (0.8)
Physical burden	1-4	2.5 (1.1)	2.7 (1.0) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]	2.5 (1.0)	2.7 (1.0) [ac]	2.7 (1.0) [bc]	2.7 (1.0) [bc]
Skill utilization	1-4	2.2 (0.8)	2.2 (0.8) [ac]	2.2 (0.8) [b]	2.3 (0.8) [bc]	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)	2.1 (0.8)
Required job quality	3-12	8.2 (2.0)	8.2 (2.0)	8.2 (2.0)	8.1 (2.0)	8.4 (1.9)	8.5 (1.9) [ac]	8.6 (1.9) [bc]	8.4 (1.9)
Interpersonal relationship	3-12	6.0 (1.9)	6.4 (2.0) [ac]	6.3 (2.0) [b]	6.6 (2.0) [bc]	6.3 (1.9)	6.5 (1.9) [ac]	6.4 (1.9) [b]	6.5 (1.9) [bc]
Stress Reaction (total)	29-116	57.4 (14.4)	61.5 (15.4) [ac]	61.0 (15.2) [bc]	62.7 (15.7) [bc]	56.3 (14.6)	58.3 (14.6) [ac]	57.9 (14.6) [b]	58.5 (14.6) [bc]
Vigor	3-12	8.5 (2.4)	8.8 (2.4) [ac]	8.7 (2.4) [b]	8.9 (2.4) [bc]	8.5 (2.3)	8.6 (2.2) [ac]	8.6 (2.2)	8.7 (2.2) [bc]
Irritation	3-12	6.4 (2.4)	7.1 (2.5) [ac]	6.9 (2.5) [b]	7.3 (2.5) [bc]	6.3 (2.4)	6.7 (2.4) [ac]	6.6 (2.4) [b]	6.7 (2.4) [bc]
Fatigue	3-12	6.9 (2.5)	7.4 (2.6) [ac]	7.4 (2.6) [bc]	7.6 (2.6) [bc]	6.5 (2.4)	6.9 (2.4) [ac]	6.9 (2.4) [b]	6.8 (2.4) [bc]
Anxiety	3-12	5.9 (2.3)	6.2 (2.4) [ac]	6.1 (2.3) [b]	6.2 (2.4) [bc]	6.2 (2.3)	6.3 (2.3) [ac]	6.3 (2.3) [b]	6.3 (2.3) [bc]
Depression	6-24	10.2 (3.7)	10.8 (3.9) [ac]	10.8 (3.9) [b]	11.0 (3.9) [bc]	10.4 (3.9)	10.7 (3.8) [ac]	10.7 (3.8) [b]	10.7 (3.9) [bc]
Physical symptoms	11-44	19.6 (5.5)	21.3 (6.1) [ac]	21.1 (6.1) [bc]	21.7 (6.2) [bc]	18.3 (5.6)	19.1 (5.8) [ac]	18.9 (5.8) [b]	19.3 (5.8) [bc]
Social Support (total)	9-36	19.7 (4.9)	20.4 (5.0) [ac]	20.2 (5.1) [b]	20.9 (4.9) [bc]	20.4 (5.1)	20.2 (5.1) [ac]	19.9 (5.1) [bc]	20.4 (5.2)
Superiors' support	3-12	7.9 (2.2)	8.2 (2.3) [ac]	8.1 (2.3) [b]	8.3 (2.2) [bc]	7.7 (2.2)	7.6 (2.2) [ac]	7.5 (2.2) [b]	7.6 (2.2)
Co-workers' support	3-12	6.8 (2.1)	6.9 (2.1) [ac]	6.8 (2.2)	7.1 (2.1) [bc]	7.2 (2.0)	7.0 (2.0) [ac]	6.9 (2.1) [bc]	7.0 (2.0) [bc]
Family support	3-12	5.0 (2.0)	5.4 (2.2) [ac]	5.3 (2.2) [b]	5.5 (2.2) [bc]	5.5 (2.2)	5.7 (2.2) [ac]	5.5 (2.2)	5.7 (2.2) [bc]

BJSQ: Brief Job Stress Questionnaire,

[a] p <0.05 vs non-smokers (unpaired t test), [b] p<0.05 vs non-smokers (Dunnett's test),

[c] p<0.05 vs non-smokers (multivariate analysis adjusted with age, BMI, amount of alcohol consumption, frequency of alcohol consumption)

BMI: body mass index

[Light smokers (LS) <15 cigarettes/day, Heavy smokers (HS) ≥15 cigarettes/day]

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	*8-9*
Study size	10	Explain how the study size was arrived at	6-7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	-
		(*e*) Describe any sensitivity analyses	8-9
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	10
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10
		(b) Indicate number of participants with missing data for each variable of interest	-
Outcome data	15*	Report numbers of outcome events or summary measures	10-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	10-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-11
Discussion			
Key results	18	Summarise key results with reference to study objectives	12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.